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AN ANALYSIS OF SEVEN CASES OF OSTEOMYELITIS OF THE FRONTAL BONE COMPLICATING FRONTAL SINUSITIS.*

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Osteomyelitis of the skull is one of the most dreaded complications of infection of the frontal sinus. Many operators, even those who have had an extensive experience, are still in a quandary as to the proper treatment of this complication. The question is whether to operate radically or to treat the case conservatively. The writer has tried both methods but his results have been indifferent. The publication of Furstenberg's paper based on his splendid series of operated cases and embodying his research work on this disease caused the writer to turn again to more radical procedures. Greater success has followed this return.

It might be said in passing that osteomyelitis of the upper jaw seems to be more amenable to conservative surgery. Judging from the cases at the Massachusetts Eye and Ear Infirmary, the writer is of the opinion that the treatment of osteomyelitis of the upper jaw should be along conservative lines; that is, the operation should be confined to the removal of diseased bone or sequestra and to

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general hygienic measures. This plan of treatment has been successful in the majority of these cases, although, to be sure, they are few in number, which have been treated in the last ten years at the Massachusetts Eye and Ear Infirmary.

The writer's connection with the seven cases here to be reported is as follows. He operated none of them, but with the exception of the third case, saw them all in consultation, gave his opinion as to the type and extent of operation to be used and was present at the first operation and most of the secondary operations. The first case was a private patient of Dr. G. H. Tobey. He did so well that the writer was inspired to advise the same procedure in the hospital cases. Here, as Chief of Staff, he had, as usual, the hearty co-operation of the various staff surgeons.

The paper is essentially clinical. It aims at completeness only in the presentation of the histology of bone and in the review of the pathological findings shown by the bone specimens removed at the various operations.

It is built around the following main points, namely, that edema of the soft-tissues of the forehead is the first sign of infection of the medulla of the bone and of the periosteum; that the edema is a practical guide to the extent of bone to be removed; that the X-ray does not give positive findings until necrosis occurs, and, therefore, is not positive until seven to ten days after the edema has shown infection of the medulla; and lastly, that radical operation—multiple radical operations if necessary—offer the best chance of success.

It is customary not to consider an operated case of osteomyelitis as cured until the patient has been free from symptoms for six to eight months. Four of the seven cases in this series are well to date. To be more specific, two cases have remained well for one year after leaving the hospital, one for six months, and the other for two months. I have never been connected with a series of cases which up to now have done so well. Neither has any series of cases at this hospital been operated in accordance with such a definite preoperative plan. The results of this series to date, backed up by the splendid series of Furstenberg, has given the writer a feeling of increased confidence in dealing with this disease. When to operate—how far to operate—how far the infection extends in the medulla of the bone, are nearer an answer in the writer's mind than they have ever been before.

This is a joint paper, as the title indicates. No attempt has been made to cite the literature completely. Only the outstanding papers will be quoted or commented on. The senior writer is responsible

for the fundamental idea of the paper, namely, that edema of the soft tissues of the forehead is a practical guide to the limit of the infection of the bone of the medulla. Most of the comments on the cases are his also. Dr. Judd is responsible for the unusually complete pathological examination of the bone specimens, and for the review of the literature. Naturally, also, he contributed the paragraphs on the histology and the pathways of infection of bone. Furthermore, many of the comments were not made except after consultation with him.

Five noteworthy papers have appeared in recent years on the subject of osteomyelitis of the skull. One unusually complete paper, namely, by Wilensky, has just appeared. Of the other four, the first two are the papers of Mackenzie (1913-1927); the third, the paper by Bulson (1925); and the fourth, the paper by Furstenberg. The papers by Mackenzie and Furstenberg should rank as landmarks in the discussion of this disease. As was just said, no attempt will be made in this paper to review the literature in detail. In speaking of literature, however, the recent masterpiece of Turner and Reynolds on "Intracranial Pyogenic Diseases" should be read by all who are interested in osteomyelitis. In the writer's opinion, this book is destined to take its place beside the classic of Mackenzie on "Suppurative Diseases of the Brain."

The order of the paper is as follows: A report of seven cases of osteomyelitis of the frontal bone with the pathological findings in each case; comments on the cases reported and general comments; the histology of bone; the pathways of infection; gross and microscopic pathology; the technique of the operation for osteomyelitis of the skull; summary and conclusions.

Case 1: R. S. I., white, male, age 16 years, was first seen by Dr. H. G. Tobey on Sept. 27, 1931. He complained of having had a swelling in the region of his right eye for twenty-four hours. This swelling had developed following a head cold.

Examination showed a swelling under pressure in the region of the right ethmoid and slight swelling of the right side of the forehead. There was slight nasal discharge but no fever or pain. The swelling was incised and a large amount of creamy pus was evacuated. Two days later, however, a distinct puffy swelling developed over the forehead and over the right eye. The patient was immediately brought into the Phillips House. X-rays at that time disclosed cloudiness of the right antrum and ethmoid. The left frontal and ethmoid were slightly hazy but the margins of both frontal sinuses were sharply defined. The soft tissues over the frontal region were

tremendously thickened and contained a bubble of air at the level of the top of the right frontal sinus.

On Oct. 5, 1931, the patient's temperature went up to 103° and the white blood count was 19,000. X-rays on this date disclosed an increased density of all the sinuses except the left antrum. The outlines of the frontal sinuses were less distinct than at the time of the previous examination.

On Oct. 6, 1931, the patient was operated on, under ether anesthesia, by Dr. George H. Tobey. An incision was made from the outer angle of the right orbit, just above the eyebrow, to the midline. A similar incision was made on the left side. From the junction of these, another incision was made upward in the midline to a point beyond the edema of the scalp which extended for one and one-half inches behind the hairline. After retracting the flaps, the bone was found to be soft and moth-eaten in appearance. The outer table was destroyed just above both frontal sinuses. A third area of destruction was found about one and one-half inches above the right frontal sinus. On drilling through the bone one inch above the right frontal sinus, a large amount of thick creamy pus escaped from between the two tables. When the inner table was removed a very large extradural abscess was found. The bone was then trephined at about the level of the hairline and at first it appeared perfectly normal. After a short time, however, pus could be seen oozing from the diploe. Going higher still, a trough was cut through the calvarium one inch below the limits of the frontal bone, by means of the Hudson drill and bone chisels. Working downward, the inner and outer tables of the frontal bone, including the anterior and posterior walls of both frontal sinuses, were removed; the operative defect extended laterally to beyond the middle of the orbital ridges. A second extradural abscess was found on the left side, apparently about the same size as the one on the right. Granulation tissue covered the dura on both the right and left sides. There was no evidence of intradural involvement. The wound was left wide open and the patient was returned to bed in fair condition.

After the operation, the patient's temperature and white blood count returned to normal and remained so throughout the rest of his stay in the hospital.

Cultures taken from the frontal sinus, ethmoid and extradural abscesses all grew staphylococcus aureus.

Check up X-rays on Oct. 14, Oct. 29, Nov. 25 and Dec. 12, 1931, were negative.

On Dec. 15, 1931, a plastic operation for removal of the extensive scar was done by Dr. Kazanjian. The patient was discharged on Dec. 26, 1931. When last seen by Dr. Tobey, on Oct. 20, 1932, the patient was apparently completely recovered and had been active in sports.

Microscopic Findings: The mucous membrane from both frontal sinuses showed an acute inflammation. That from the right side (see Fig. 1) was thickened and densely infiltrated with inflammatory cells. There was vascular congestion and several of the smaller vessels

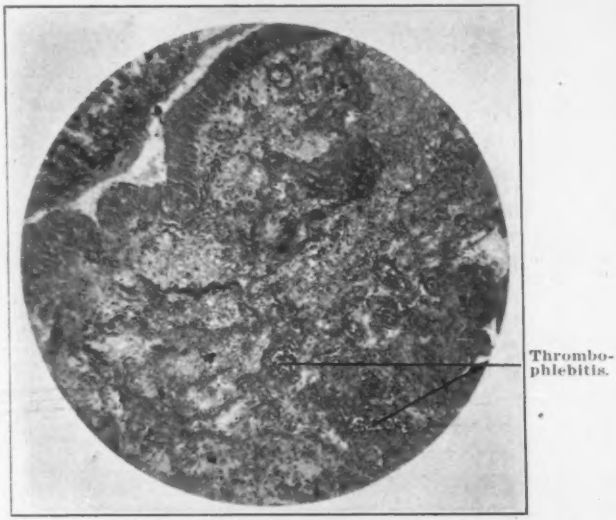

Fig. 1. This section demonstrates thrombophlebitis in the blood vessels of the mucous membrane from the right frontal sinus.

showed septic thrombosis. The mucous membrane of the left frontal sinus (see Fig. 2) was likewise thickened and infiltrated. The epithelium was partly degenerated and the surface was covered with pus and fibrin.

A specimen from the anterior wall of the right frontal sinus (see Fig. 3) showed marked destruction and erosion of the bone. Granulation tissue and pus filled the bone spaces. There was considerable lacunar resorption and sequestration.

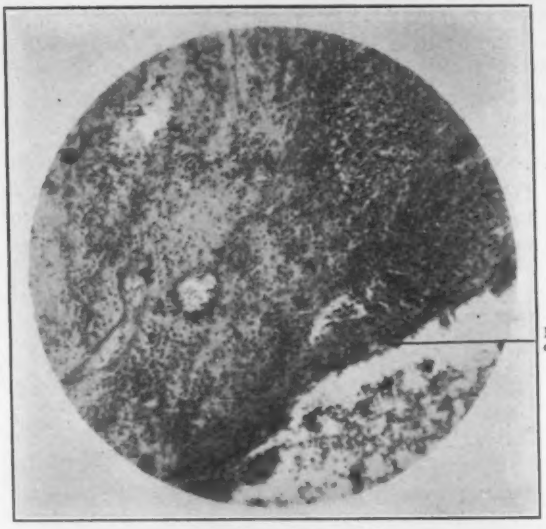

Fig. 2. This section of mucous membrane from the left frontal sinus shows infiltration with polymorphonuclear leukocytes. The epithelium is destroyed and the surface is covered with pus and fibrin.

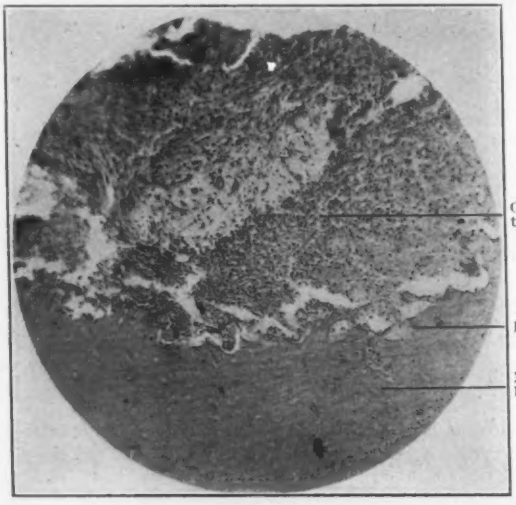

Fig. 3. This specimen of bone from the anterior wall of the right frontal sinus shows erosion along the bone margin. Granulation tissue fills the diploetic space. The bone is necrotic and the osteocytes have been destroyed.

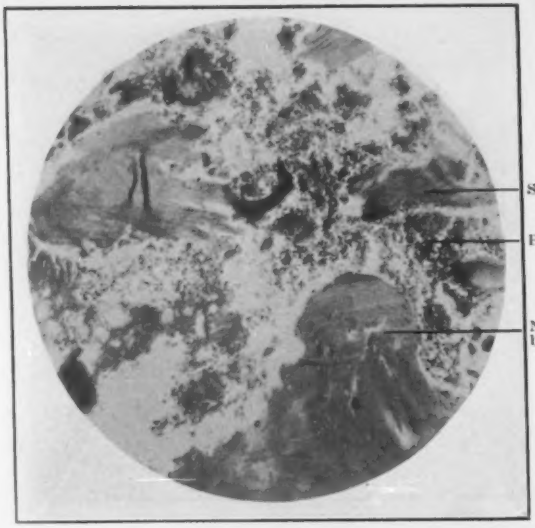

Fig. 4. The bone in this specimen from the anterior wall of the left frontal sinus shows marked destruction. It is necrotic and there are numerous small sequestra. The bone spaces are filled with pus.

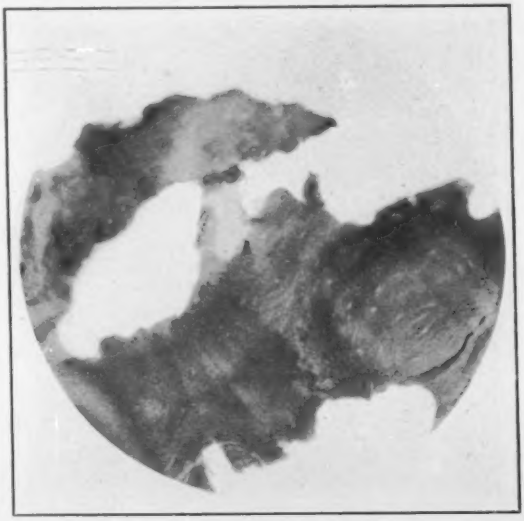

Fig. 5. The necrotic bone shown in this section was taken from the posterior wall of the right frontal sinus. The lacunae are enlarged and empty and the characteristic lamellar arrangement of the bone structure is lost.

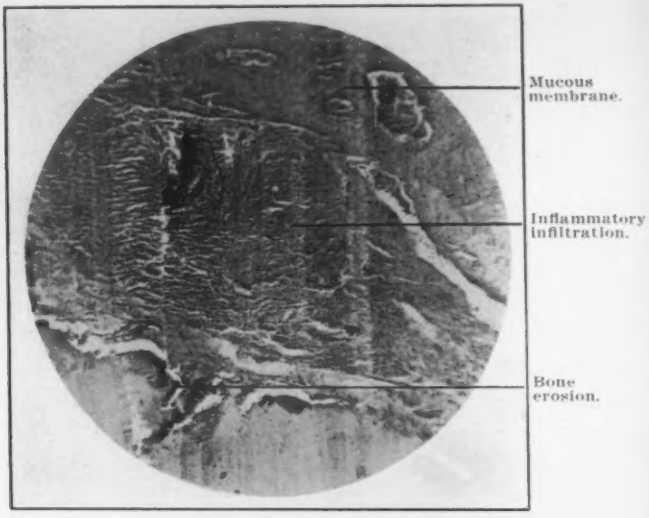

Fig. 6. This section shows mucous membrane attached to the bone of the posterior wall of the left frontal sinus. Near the bone, the inflammatory infiltration into the mucous membrane is very dense. The margin of the bone is very irregular as a result of erosion.

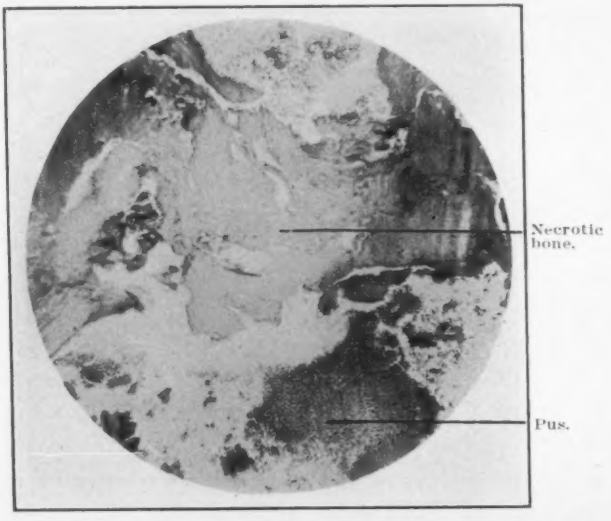

Fig. 7. This section shows necrotic bone taken from the outer table of the frontal bone above the sinus. The bone is eroded, irregular and bathed in pus.

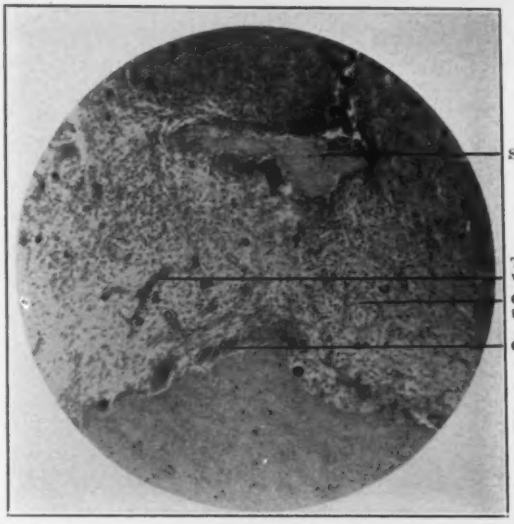

Fig. 8. This specimen of bone was obtained from one and one-half inches above the left frontal sinus. The margin of the bone is lined by osteoclasts. A sequestrum of necrotic bone lies free in the granulation tissue. Several of the blood vessels show septic thrombosis.

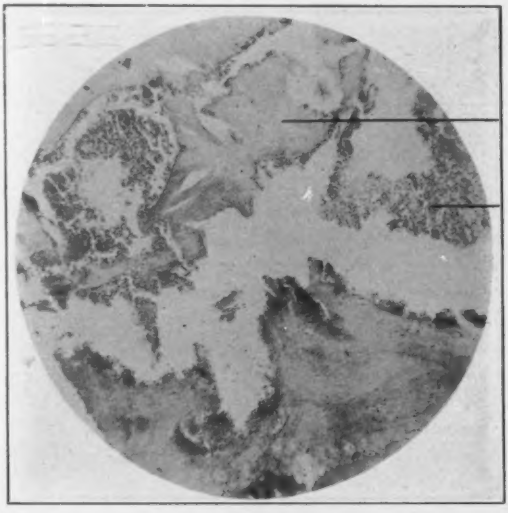

Fig. 9. This section shows acute osteomyelitis in a specimen of bone taken from one and one-half inches above the right frontal sinus. The bone is necrotic and irregularly eroded. The bone spaces are filled with pus.

Bone from the anterior wall of the left frontal sinus (see Fig. 4) was very irregular and filled with granulations and pus. Many areas of the bone were necrotic and there were numerous sequestra. Osteoclastic activity was not marked.

The posterior wall of the right frontal sinus (see Fig. 5) consisted of thin necrotic bone. Resorption was marked and the lacunae were enlarged and empty. The normal structural form of the bone was lost.

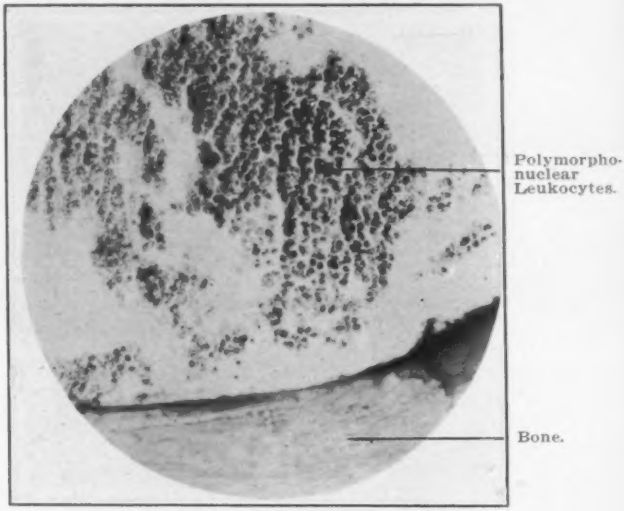

Fig. 10. This specimen, which was removed from the frontal bone at the level of the hair line, shows the bone structure to be intact and without erosion of the margin. However, the medullary space is filled with pus cells.

There was mucous membrane attached to the bone (see Fig. 6) removed from the posterior wall of the left frontal sinus. This mucous membrane was edematous, acutely inflamed, and partially denuded of epithelium. All of the vessels were congested and many of them were thrombosed. The inflammatory cells were especially numerous along the surface of the bone, which was eroded and irregular. Bone destruction was quite marked but in a few places new bone formation was taking place.

A fragment of the outer table (see Fig. 7) taken from the defect in the bone above the left frontal sinus was entirely necrotic. The

Haversian systems were empty and the normal structural arrangement of the bone was indistinct. This bone was bathed in pus.

Bone specimens from one and one-half inches above the left frontal sinus (see Fig. 8) showed acute osteomyelitis. The bone spaces were filled with granulations and pus in which lay small irregular sequestra. The vessels were congested and thrombophlebitis was found in some of them. The margins of the bone were lined by osteoclasts and destruction was marked.

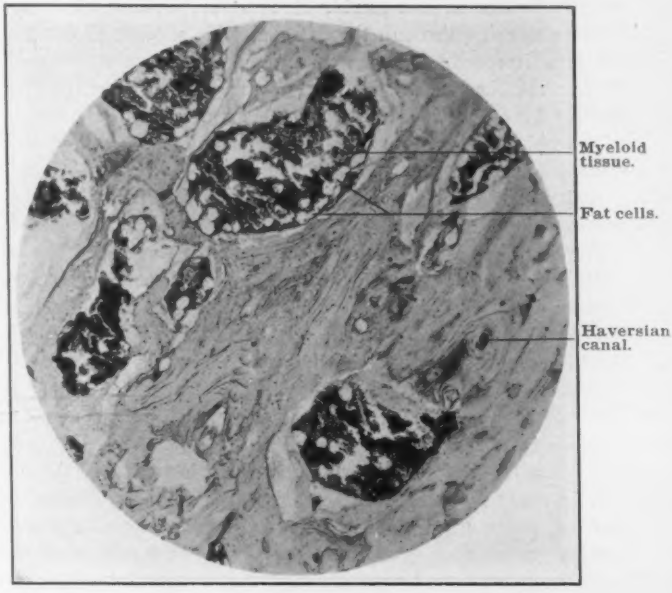

Fig. 11. This section shows normal bone obtained from the upper limits of the operative defect in the frontal bone. The bone structure is intact and the medullary spaces are filled with normal myeloid tissue.

Bone from one and one-half inches above the right frontal sinus (see Fig. 9) was for the most part necrotic. The medullary spaces were filled with pus and there was considerable osteoclastic activity.

A specimen was removed from the right side at about the level of the hairline where, shortly after a trephine opening was made, pus had been seen oozing from what was apparently normal bone. In this specimen (see Fig. 10) the bone spaces were filled with pus

cells. However, there was as yet no destruction or necrosis of the bone structure.

Examination of a specimen taken from the upper limit of the operative defect (see Fig. 11), that is, one inch below the fronto-parietal suture, showed the bone to be normal.

COMMENT.

On drilling through the bone one inch above the right frontal sinus, a large amount of thick creamy pus escaped from between the two tables of the skull, and when the inner table was removed a large extradural abscess was found. Even at the hairline an exploratory trephine opening through the external table showed at first nothing, but in a few seconds pus was seen coming from the diploe. Still further up, that is, one inch below the parietal bone, the trephine opening was negative, and the bone appeared to be normal. The microscopic examination of the specimen removed at this point showed normal bone.

Both the anterior and posterior walls of the frontal sinuses were removed.

The organism found in the culture was the staphylococcus aureus.

The smaller vessels of the mucous membrane showed septic thrombi. The frontal bone showed septic thrombi in the medulla. The mucous membrane of the posterior wall of the frontal sinus, like the anterior wall, showed thrombosed vessels.

One could not ask for a more satisfactory case. The operator went beyond the edema into normal bone, and no secondary operations were necessary. This is the ideal to be aimed at. The temperature fell after the operation and remained down. Only the floor of each frontal sinus was left. Both nasofrontal ducts became obliterated and the space previously occupied by the frontal sinuses filled in with granulations. At first there was some question as to what would happen to the frontal sinuses. It was hoped that granulations would obliterate them, and this is what happened. After the plastic operation for the replacement of the skin flap, only a moderate depression of the skin of the forehead remained.

The organism, as I just said, was the staphylococcus aureus. This is the usual organism found in osteomyelitis of the skull. Occasionally streptococci and pneumococci are found, according to writers on the subject, and cases in which they are found are often fatal. Skillern states that in all cases in which the staphylococcus aureus is found the patients get well. Wilensky, however, feels that this statement is too strong and not as yet substantiated by clinical cases.

In this case Dr. Tobey used a dressing of a stock bacteriophage and feels that it kept the wound exceptionally clean.

Even if the exploratory trephine opening into the diploe does not at first show pus, it may appear as in this case after waiting a few seconds. This point was mentioned above. It is repeated because it is worth bearing in mind.

Case 2: G. S., white, male, age 14 years, entered the Massachusetts Eye and Ear Infirmary, Nov. 5, 1931, complaining of a discharging fistula in the left upper eyelid. Two months previously he had been swimming in a stone quarry. The next day he developed a severe left frontal headache quickly followed by swelling of the left side of the forehead. After one week the headache ceased, but the swelling increased, closing the left eye. His temperature was elevated during this time, frequently as high as 103°. Poultices had no effect and so, two weeks after the onset, his physician incised the swelling of the forehead and evacuated a considerable quantity of yellow pus. Two weeks later it was necessary to incise the swelling of the left upper eyelid. Following this, the entire swelling disappeared and the first incision healed. The wound in the eyelid, however, remained open and continued to discharge a moderate amount of yellow pus. At no time were there symptoms of intracranial disturbance. He had been active and feeling well for three weeks prior to admission, but was advised to enter the hospital by the family physician because of increasing discharge from the fistula. His past history disclosed occasional mild head colds but no evidence of sinus infection.

Examination revealed the nasal fossae to be normal except for slight congestion of the turbinates on the left side. The left eye was displaced slightly downward but all extraocular movements were normal. There was a palpable depression along the left supraorbital ridge as though due to bone destruction. Pressure at this point produced pain and caused pus to exude from the palpebral fistula. His temperature was normal. The white blood count was 10,600.

X-rays on the day of admission showed osteomyelitis of the anterior wall of the left frontal sinus and the margin extending into the skull. By X-ray the bone was involved for one inch above the upper rim of the left orbit. The right side was negative.

On Nov. 9, 1931, four days after admission, the first operation was performed by Dr. H. G. Tobey. The frontal bone was exposed by an incision from the outer angle of both orbits, through the eyebrows, to the midline and a second incision extending from the first upward in the midline to the hair margin. Immediately over the

left frontal sinus, and above it, the bone was darkened and partly necrotic. Surrounding this, there was an area of soft but intact hemorrhagic bone. Aside from this area the bone appeared normal. A series of trephine holes was made through both tables of the skull to surround the upper, lateral and medial margins of the discolored bone. These openings were connected by means of a chisel. The operation was discontinued at this stage because of the patient's weakened pulse and lowered blood pressure.

One week later, on Nov. 16, 1931, under avertin and ether, the second stage of the operation was done. After removing the granulation tissue, both tables of the left frontal bone, including the anterior and posterior walls of the left frontal sinus, were removed, from the trephine openings made previously, down to the supraorbital ridge. The right frontal sinus was then opened and though it did not contain pus, the bone of the anterior wall was very soft. For this reason, a trench was made through the right frontal bone about two inches above the supraorbital ridge similar to that previously made on the left side. At this point the operation was stopped because the loss of blood had been considerable.

On Nov. 20, 1931, X-rays revealed no evidence of osteomyelitis.

On Nov. 28, 1931, under avertin and ether, the third stage of the operation was performed. The island of bone remaining in the midline and on the right was exposed by scraping off granulations. It was separated from the dura and superior longitudinal sinus by blunt dissection. Its attachment to the posterior wall of the sinus was cut through with a rongeur and the bone was lifted off. The bone along the right and left lateral margins of the surgical defect was removed with a rongeur for about one-half an inch. The wound was left wide open and the patient was returned to bed in good condition.

Following this operation, the wound remained comparatively clean and the patient was able to be out of bed within a week.

However, on Dec. 9, 1931, X-rays showed an extension of the osteomyelitic process upward in the midline for about one inch beyond the margin of the operative defect.

Accordingly, on Dec. 10, 1931, the fourth operation was done. By means of a Hudson drill and chisel, the bone was removed for two and one-half inches above the previous upper margin.

Cultures taken from the fistula and at all operations grew staphylococcus aureus.

After this procedure the patient rapidly improved and was discharged to the out-patient department on Dec. 23, 1931. The wound was practically healed.

A plastic operation was done by Dr. Kazanjian on May 10, 1932, to remove the extensive scar over the forehead.

The patient still returns for observation, but has remained well and active without any evidence of recurrence of the disease.

Microscopic findings; specimen from the first operation:. Bone from just above the left frontal sinus showed acute osteomyelitis, with erosion of the bone structure. The medullary spaces and Haversian canals were filled with pus. The bone was largely necrotic with considerable osteoporosis. There were numerous small sequestra lying in pus and surrounded by osteoclasts.

Specimens from the second operation: The mucous membrane from the left frontal sinus was acutely inflamed. There was a dense infiltration of cells, chiefly polymorphonuclear leukocytes. The vessels were congested and there was considerabel hemorrhage. However, no thrombophlebitis could be seen. The epithelium was almost entirely degenerated and the surface of the membrane was covered with pus and fibrin.

The mucous membrane from the right frontal sinus was also acutely inflamed. It was thickened, edematous and infiltrated with polymorphonuclear leukocytes and lymphocytes. Vascular congestion was marked but there was no thrombosis. The epithelium was intact.

Bone from one inch above the left frontal sinus showed acute osteomyelitis. The myeloid tissue was partially degenerated, and densely infiltrated with polymorphonuclear leukocytes. Three or four of the small medullary vessels were thrombosed. The bony margins were irregular and there was marked osteoclastic activity, both in the medullary spaces and in the enlarged Haversian canals.

Sections taken from above the outer angle of the right eye (apparently unaffected region) showed acute inflammation of the myeloid tissue. There was dense infiltration with polymorphonuclear leukocytes and lymphocytes. The inflammation extended into the Haversian canals with thrombosis of some of the vessels. However, there was no evidence of erosion or osteoclastic activity.

Specimens from the third operation: Section from the right frontal bone. Where previously there was only infiltration into the myeloid tissue, there was now definite destruction of the bone structure. The myeloid tissue was replaced by granulations infiltrated with acute inflammatory cells and there was considerable osteoporosis. The irregular margins of the bone were lined by osteoclasts. A few areas of the bone appeared necrotic with enlarged empty lacunae.

Section of bone from the midline showed necrosis. Lacunar resorption was quite marked.

Specimens from the fourth operation: Bone from two inches above the upper limit of the previous bone defect showed inflammation of the myeloid tissue. There was marked infiltration of polymorphonuclear leukocytes and lymphocytes into the medullary spaces. However, there was no apparent damage to the bone structure.

Bone from the highest limit of the newly established defect was normal.

COMMENT.

With the bone of the front wall of the frontal sinus already infected and necrotic, it was found that the medulla also was infected for at least two inches above the necrotic area. Therefore, the first operation was done too near the necrotic bone.

In the second operation, the myeloid tissue was found on microscopic examination to be infected, although the bone appeared to the eye to be normal.

In the bone above the left frontal sinus, the medullary vessels showed septic thrombi.

At the third operation, bone which was only infiltrated at the second operation now showed definite destruction.

At the fourth operation, two inches above the upper limit of the operative defect made at the third operation, there was infection of the myeloid tissue. Two inches above this, the bone was normal.

This case shows that the bone removal can be done in several stages if the patient's condition at any time prohibits prolonged operation. It shows also that only at the fourth operation, and when the hairline was reached, did the operator come to normal bone. On reaching normal bone, this was the last operation necessary.

Case 3: W. J. R., white, male, age 16 years, was admitted on Nov. 30, 1931, to the Massachusetts Eye and Ear Infirmary, under the care of Dr. Cahill.

On the first of September, after having been swimming, the patient complained of severe frontal headache. Two days later a swelling appeared over the right eye and the headache disappeared. He developed a slight fever, which continued for ten days. His physician then incised the frontal swelling and evacuated a considerable quantity of pus. The wound healed after discharging for about one week. Six weeks later, after X-ray examination had disclosed clouding of the right frontal sinus, a radical frontal operation was done at a local hospital. The surgeon found a perforation of the posterior wall of the sinus with exposure of the dura. After three weeks in the hospital, the patient returned home but on two occasions since that time he vomited and, according to his family, he was "dull mentally" most of the time.

When examined, on admission to the Infirmary a few days later, the patient appeared extremely ill. He was drowsy and answered questions very slowly. There was edema of the left side of his forehead extending for about three inches above the left supra-orbital ridge. There was a general weakness and the sphincter reflexes were gone. An eye examination disclosed papilloedema of 4 to 5 diopters in both eyes with a few hemorrhages and exudate around the discs. There was paresis of both internal recti. His temperature was 100°, the white blood count was 15,000, and the red blood count was 3,900,000. His spinal fluid pressure was 550 but the cell count was normal.

X-ray examination showed osteomyelitis of the frontal bone extending for one and one-half inches above the right frontal sinus.

On Dec. 2, 1932, three days after admission, Dr. Cahill operated on the patient. The remainder of the posterior wall of the right frontal sinus was removed, and above this a circular area of bone two inches in diameter was removed from the right frontal bone. The dura was incised, and the right frontal lobe of the brain was probed for an abscess without result. The patient's condition became so poor that no more bone could be removed. The wound was left wide open.

The next day the patient was semicomatose. His white blood count was 18,900 and his temperature rose to 103°.

On the third postoperative day, the patient appeared considerably improved, answering questions and taking fluids. His temperature came down to 101°.

Two days later, however, the patient became unconscious. The spinal fluid pressure was 350 and culture showed staphylococcus albus. Cultures from the wound and infected bone grew staphylococcus aureus.

The patient's condition gradually became worse and by Dec. 11, 1932, his temperature reached 106.6°. On the morning of Dec. 12, 1932, he died.

Permission for autopsy was not obtained but the cause of death was apparently meningitis.

Microscopic Findings: Sections taken from several areas of the bone removed at operation all showed an acute osteomyelitic process. The medullary spaces were filled with pus and granulations. The margins of the bone were eroded and many areas were necrotic. Osteoclasts were numerous. The bone from the upper margin of the operative defect showed a moderate inflammation of the myeloid tissue but there was only slight erosion. The periosteum attached to

this bone, however, was slightly edematous and quite markedly infiltrated with polymorphonuclear leukocytes.

COMMENT.

This case had his radical frontal sinus operation performed outside this hospital. On admission to the Infirmary there were definite signs of a brain abscess. As no autopsy was obtained, the presence of an abscess cannot be proved. Undoubtedly, however, there was meningitis. He had osteomyelitis as shown by X-ray and by the microscopic findings of the bone specimens which were removed. The boy was too ill for a systematic attempt to be made to cope with the osteomyelitis. It is important to note that the periosteum attached to one of the bone specimens taken from the upper limit of the operative defect was edematous and acutely infected.

Case 4: T. W. W., white, male, age 20 years, was admitted on March 2, 1932, to the Massachusetts Eye and Ear Infirmary on the service of Dr. Barnes.

The patient complained of having had left supraorbital headache for nine days and swelling of the left eye for three days. He had a convulsion on the evening of admission.

He had had many head colds during the winter but there were no severe symptoms until nine days before admission. At that time the left supraorbital headache was first noted. It had been present every day since that time, being more severe the first two or three hours after waking in the morning. Also there was considerable discharge from the left nostril. On the day after onset of headache, he developed severe pain in the left side of his face, which was relieved after extraction of the first upper left molar tooth. Three days before admission, the left upper eyelid and lower left side of his forehead became swollen and tender. His symptoms were not relieved by sprays. Just before entering the hospital, he "stiffened all over and became unconscious," remaining so for nearly thirty minutes. During this time there were no movements, salivation or incontinence.

On examination, the patient appeared to be very ill. Marked swelling involved the left upper eyelid and the soft tissues over the left frontal sinus. There was extreme tenderness over this sinus. The left nostril was occluded by swollen turbinates and filled with purulent secretion. His temperature was 102°, and the white blood count was 10,000. The urine and spinal fluid were negative.

He was immediately taken to the operating room. Under ether anesthesia, an incision was made to expose the lacrimal bone. This was found to be necrotic, and pus welled up from the ethmoid

region. A rubber drain was inserted and the patient was returned to bed.

The next day the swelling and pain were considerably lessened but there was a great deal of purulent discharge both from the left nostril and from the incision.

X-rays taken on March 3, 1932, the day after admission, showed a left pansinusitis with pus present in all sinuses. The outline of the frontal sinus appeared intact.

On March 6, 1932, four days after admission, a lumbar puncture revealed spinal fluid under an initial pressure of 280 m.gm. and a final pressure of 120 m.gm. There were 600 cells with 93 per cent polymorphonuclear leukocytes. Tests for globulin and sugar were positive.

Under avertin and ether, a left radical frontal and ethmoid operation was done by Dr. Meltzer. On exposing the lacrimal bone, a large perforation was found through which came creamy pus under pressure. The floor of the left frontal sinus was removed with a Kerrison punch, permitting the escape of thick pus. The mucous membrane was reddened and slightly thickened; the bone was bare in places. Extensive frontal and orbital ramifications were exposed but throughout the posterior wall of the sinus appeared intact. The floor and part of the anterior wall were removed. The ethmoid cells were filled with thickened polypoid membrane and a moderate amount of creamy pus. The cell partitions were soft but the roof of the ethmoid appeared intact. After removing the major part of the lamina papyracea, the ethmoid cells and polypoid membrane, a rubber drain was inserted and the wound left open.

On March 7, 1932, lumbar puncture released spinal fluid under an initial pressure of 200 m.gm.; the final pressure was 75 m.gm. The white cell count was reduced to 300 with 90 per cent polymorphonuclear leukocytes. Globulin was present, but no sugar. However, the patient appeared very much worse.

Dr. G. C. Caner, of the neurological service, after examining the patient, reported the following: "The patient has a stiff neck and bilateral Kernig, more marked on the left. There is a positive Oppenheim on the right but no other evidence of pyramidal disease. Spinal fluid findings suggest that the meningitis reaction is clearing up. No definite evidence of brain abscess."

The next day (six days after admission), under ether anesthesia, the old incision was reopened. The frontal sinus contained pus and blood clot. The remainder of the anterior wall of the sinus was removed. The intersinus septum was then taken down and the right

frontal sinus was found to be filled with pus under pressure. A small discolored area was found on the posterior wall of the left frontal and, after removing it, pus exuded from an extradural abscess immediately beneath. Accordingly, the entire posterior wall was removed up to the common wall and beyond. At every bite of the punch, pus exuded from between the two tables of bone. The anterior and posterior walls of the right frontal sinus were also removed. With a rongeur both tables of the frontal bone were then removed to within one inch of the hairline. At no place, however, was normal dura exposed, and the end of the infected diploe was not reached. The poor condition of the patient made cessation of the operation imperative.

The next day the patient appeared somewhat improved. The stiff neck was less marked and the spinal fluid cell count was down to 41 with 80 per cent polymorphonuclear leukocytes. X-rays showed no evidence of osteomyelitis.

However, because of the infected bone previously found and because the patient's temperature went up to 103°, further surgery was decided upon.

On March 10, 1932 (eight days after admission), under avertin and ether, a vertical incision was made from the old wound upward, in the midline, to the vertex. The flaps thus made were laid back laterally, exposing all of the frontal bone and part of the parietals. A large area, including practically all of the frontal bone, was outlined by drill holes. These openings were connected by means of a chisel. The bone was then separated from the dura and the superior sagittal sinus and removed in one piece. The surface of the exposed dura was covered by numerous collections of pus. However, for a distance of one-half to one inch below the bone margin, the dura appeared quite normal. An opening was made through the dura over the right frontal lobe and a small amount of pus escaped. With diathermy a round area was outlined over each frontal lobe, through which a Cushing needle was introduced into the brain. No abscess could be found. The pus first found had evidently come from the subarachnoid space.

The postoperative condition of the patient was very poor.

During the following two weeks the patient at first seemed improved but gradually became worse. Lumbar puncture on March 16, 1932, showed an initial pressure of 175 m.gm.; the final pressure was 75 m.gm. The spinal fluid had a yellow tinge; the cell count was 600 with 72 per cent polymorphonuclear leukocytes. Tests for sugar were negative and globulin was present. The patient's tem-

perature rose to 104° on March 22, 1932, and he lost consciousness. On March 23, 1932 (21 days after admission), he died.

Permission for autopsy was not obtained. The cause of death in all probability was meningitis.

Bacteriology: All cultures from the sinuses and operative wound showed staphylococcus aureus. Cultures from the spinal fluid on March 9, 1932, and March 15, 1932, showed staphylococcus aureus.

Microscopic findings; specimens from second operation (radical frontal and ethmoid): The mucous membrane from the left frontal sinus showed a very marked acute inflammatory reaction. The section for the most part consisted of pus and fibrin. The mucous membrane itself was thickened, edematous and very densely infiltrated with lymphocytes and polymorphonuclear leukocytes. The blood vessels were engorged but no septic thrombus could be found.

Bone removed from the anterior wall of the left frontal sinus showed an acute osteomyelitis. The myeloid tissue was quite markedly infiltrated with polymorphonuclear leukocytes. There was, however, only a slight amount of erosion. Much of the bone was necrotic.

Specimens from the third operation: Bone from the posterior wall of the left frontal sinus was necrotic. The Haversian systems were empty and the lacunae were enlarged. A specimen of the anterior wall of the right frontal sinus showed necrotic bone. Some of the bone spaces contained a small amount of pus.

Bone from above the frontal sinuses showed acute osteomyelitis. The myeloid tissue of the diploe and Harversian canals was densely infiltrated with polymorphonuclear leukocytes and lymphocytes. In some places there was a moderate amount of erosion of the bone margins but generally there was very little alteration of the bone structure.

Specimens from the fourth operation: Bone from one and one-half inches above the right frontal sinus showed a moderate inflammatory infiltration of the bone medulla. There was very little bone erosion but there was considerable necrosis.

Bone from one and one-half inches above the left frontal sinus was partially necrotic and the medulla was infiltrated with quite a large number of polymorphonuclear leukocytes. However, there was not much bone destruction.

Bone from the midline, two and one-half inches above the frontal sinuses disclosed a moderate inflammatory infiltration of the myeloid tissue. However, there was no evidence of bone destruction and there were no thrombosed vessels.

Bone from the highest point of the operative defect on the left side was normal. There was no evidence of infiltration or bone destruction.

COMMENT.

This patient came to the hospital very ill. There was edema of the left upper eyelid and the soft tissues over the left half of the frontal bone. In three days the patient had a definite meningitis.

The first operative procedure was merely palliative. Then came the radical operation on the frontal sinus and the ethmoid. Discolored bone was found in the posterior wall of the left frontal sinus, and beneath this, there was an epidural abscess. Bone was removed to within an inch of the hairline. The dura which was uncovered was not normal.

The staphylococcus aureus was found both in the wound and in the spinal fluid.

In the examination of the bone specimens, the medulla of the bone two and one-half inches above the frontal sinus was reported as moderately infiltrated with inflammatory cells. The bone at the upper limit of the specimen removed showed no evidence of infiltration or bone destruction.

The evacuation of pus on the night of the patient's admission to the hospital by making an incision over the lacrimal bone, was (as was just said) merely palliative. The operation on the ethmoid and frontal sinuses was not done for three days, at which time the patient had meningitis. This proved to be a vain attempt to catch up with the osteomyelitis. When normal bone was finally reached, the patient was moribund from meningitis. No osteomyelitis at any time was shown by the X-ray.

The writers have proved to their satisfaction that the X-ray is ten to twelve days behind the infection of the medulla of the bone. When the X-ray is positive, the infection in the medulla is two to two and one-half inches beyond the spot of necrosis shown on the plate. The moral of this is, it is never safe to wait for positive findings in the X-ray.

The writer feels that both frontal sinuses should be explored in any operation undertaken for osteomyelitis of the frontal bone.

Case 5: D. G., white, female, age 22 years, entered the Massachusetts Eye and Ear Infirmary on April 22, 1932, under the care of Dr. Garland.

She complained of swelling and tenderness over the left frontal region and upper left eyelid, inability to open the left eye, convulsions, stiffness of the neck and sore throat — all of one day's duration.

Ten days previous to hospitalization, the patient developed a "grippy cold." Her physician found a membrane in her throat, but cultures were repeatedly negative for diphtheria. Antistreptococcic serum was used and the patient was apparently greatly improved until the day before admission. At that time she had a severe pain over the left side of her face, and her physician informed her that she had sinusitis. In the afternoon she had a convulsion which lasted for several minutes. After this, the pain in her face became more severe and she also noticed sore throat and tenderness over the left eye. By evening her temperature had reached 103° her left eyelid became red and swollen, and she lapsed into a semicomatose state. At midnight, she had a convulsion, followed by two more within a period of four hours. She was brought to the emergency ward at 4:30 a. m.

On examination, the patient's left eye was closed, the upper lid being red, swollen and tender. There was a swelling over the left side of her forehead, extending about one and one-half inches above the left frontal sinus. There was bilateral exophthalmos, more marked on the left, and the movements of the left eye were definitely restricted. Both discs appeared normal. The nasal mucous membrane was congested and swollen, producing a complete blockage of the left nostril and a partial blockage of the right. The faucial and pharyngeal mucosa was highly inflamed, and covered with patches of whitish membrane. The tonsils were absent.

Neurological examination gave the following positive signs: stiff neck, bilateral Kernig, patellar and Achilles reflexes absent. Her temperature was 105°; pulse, 140; and respirations, 30. The white blood count was 22,900, with 93 per cent polymorphonuclear leukocytes. The spinal fluid showed 175 cells but no bacteria, globulin or sugar. Her spinal fluid Wassermann was negative.

X-rays taken on the day of admission showed a left pansinusitis with pus in the ethmoids and antrum and thickening of the mucous membrane in the left frontal. There was increased density in the bone.

On April 23, 1932 (the next day), the patient again became unconscious. Edema of the left frontal region extended about three inches above the left supraorbital ridge.

Under ether anesthesia, the patient was operated on by Dr. Lurie. Curved incisions were made through both eyebrows and from these a vertical incision was continued upward over the midline of the forehead for five inches. After exposing the frontal bone, a trephine opening was made to the left of the midline at the upper limit of

the edema previously noted over the left frontal region, *i. e.*, about two inches above the left frontal sinus. Grossly the bone did not appear to be diseased. The exposed dura was injected and covered by a fine fibrinous exudate. Another trephine opening was made three-fourths of an inch to the left of the first and the two were connected by means of a chisel. The two tables of the bone were then removed down to the frontal sinus. At one point, a small amount of yellowish pus escaped from the diploe.

The anterior wall of the left frontal appeared decidedly whiter than the surrounding bone. During its removal there was no bleeding. The frontal sinus contained serous material and a thickened membrane, which was removed. The posterior wall appeared normal and was left intact except for the upper part, which had been removed together with the common wall. The operation had to be discontinued because of the patient's condition.

Culture from the left frontal showed hemolytic streptococcus.

After this operation the patient remained unresponsive for four days, then began to answer questions. However, during the night of April 27, 1932, she had a convulsion lasting for thirty minutes. Her temperature was 100°. Spinal fluid showed 450 cells but no growth on culture.

On April 29, 1932, an external ethmoid operation was done. The ethmoid was entered through the lacrimal bone and considerable thick pus was encountered. The cells were exenterated and the left sphenoid was opened.

On examining the dura exposed at the previous operation, pus was seen coming from a rupture in the dura about 1 c.m. above the left frontal sinus. This opening was enlarged to insure drainage from a small abscess found in the left frontal lobe.

The next day the patient's general condition was much improved but there was considerable discharge from the head wound.

On May 4, 1932, the patient comp'ained of severe headache and vomited several times. The vomiting was of the projectile type. However, her temperature was normal and there were no localizing signs. There was marked ciliary and conjunctival injection in the left eye. The left disc was slightly blurred above, temporally and below, but there were no hemorrhages or exudates.

These symptoms and signs continued and on May 10, 1932, it was decided to explore for a brain abscess. A Cushing needle was introduced through the back wall of the small cavity previously found in the left frontal lobe, and, at a depth of 2 c.m., thick pus was obtained. Culture of this material revealed staphylococcus aureus.

The patient still complained of headache and vomited occasionally during the next two days. An eye consultant on May 12, 1932, reported blurring of the right disc and one diopter papilloedema in the left eye.

Under ether anesthesia, Dr. Garland reopened the wound over the forehead. With rongeurs, the previous bone defect was enlarged in all directions, removing also a part of the posterior wall of the left frontal sinus. There was a herniated area in the region of the brain abscess. This was removed with scissors, leaving a wide opening into the abscess. Pus discharged profusely through the opening.

Recovery after this operation was slow. Daily fundus examination until May 19, 1932, revealed papilloedema of one diopter in the right eye, and three to four diopters in the left eye.

After that date, however, the eye findings gradually disappeared, the symptoms abated and the discharge ceased.

When discharged to the out-patient department on July 3, 1932, the patient was feeling well and the wound was practically healed.

Examinations since that date have shown no evidence of extension of the disease.

Microscopic findings; specimens from the first operation: Specimens of mucous membrane from the anterior and posterior wall of the left frontal sinus were acutely inflamed and largely replaced by granulation tissue. The epithelium was degenerated. The stroma was markedly edematous and densely infiltrated with polymorphonuclear leukocytes and lymphocytes. No thrombosed vessels were seen.

Bone from the anterior wall of the left frontal sinus was necrosed. The bone structure showed very little alteration but the cellular elements of the medulla and Haversian systems were missing and the lacunae were enlarged.

Bone from the posterior wall of this sinus was likewise necrotic. Here, however, there was considerable destruction and erosion of the bone.

Bone from just above the left frontal sinus showed an acute osteomyelitis. The myeloid tissue was infiltrated with numerous polymorphonuclear leukocytes and the margins of the bone were irregular as a result of erosion. A large part of this bone appeared necrotic.

Bone from one and one-half inches above the frontal sinus was intact. Though there was no bone destruction, there was a definite infiltration of polymorphonuclear leukocytes into the diploetic space. Periosteum covering the outer table was edematous and moderately

infiltrated with inflammatory cells. Its blood vessels were congested.

Bone from the upper limits of the operative defect appeared normal. There was no evidence of infiltration or destruction here, and apparently the surgeon had succeeded in getting beyond the limits of the infection.

Specimens from the second operation: The mucous membrane from the left ethmoid was acutely inflamed. It was thickened, edematous and densely infiltrated with polymorphonuclear leukocytes. There was endothelial proliferation of the small blood vessels but none were definitely thrombosed. The epithelium was degenerated.

Sections of the lacrimal bone showed an acute osteomyelitis with marked destruction. The bone spaces and Harversian canals were filled with pus. The borders of the bone were eroded and irregular. There was considerable osteoclastic activity.

Bone from the center of the os planum was slightly irregular on its inner surface but otherwise not definitely diseased. The periosteum on the orbital surface, however, was edematous and infiltrated with a moderate number of polymorphonuclear leukocytes, and lymphocytes.

Specimen from the final operation: Brain tissue removed from the region of the abscess in the left frontal lobe revealed necrosis and acute inflammation. The necrotic brain tissue was partially replaced by granulations. There was a dense polymorphonuclear leukocytic infiltration.

COMMENT.

No member of the staff expected this patient to live. She entered the hospital with meningitis. She proved, however, to be one of those cases which are seen occasionally, where a meningitis without organisms in the spinal fluid, for some unknown reason, gets well. The meningeal infection came either from the frontal sinus or the ethmoid, probably from the ethmoid. The brain abscess was probably of traumatic origin as a tear occurred in the dura at the first operation. Even the desperate complication of a brain abscess was surmounted by the patient.

The findings in the mucous membrane of the frontal sinus and in the bone specimens removed at operation were those to be expected, and were the same as those reported in the specimens from the other cases. The findings in the ethmoidal labyrinth showed osteomyelitic changes in the lacrimal bone similar to those found in the frontal bone. In spite of the fact that the whole ethmoidal labyrinth was full of pus, the osteomyelitic process could be demonstrated only half-way back on the os planum.

The bone three inches above the supraorbital ridge, that is, a little above the hairline, was found to be normal. No reinfection of the bone at the edge of the operative defect occurred. The common cause of extension of osteomyelitis in many cases is infection from the operative field.

What the writer is about to say in regard to this very splendid case may seem hypercritical. By taking advantage of hindsight he would, however, make this suggestion. The frontal and ethmoidal operation (the patient's condition permitting it) should have been done in one sitting. If it was known that the operation was to be done in two stages, the operator had the choice of doing the frontal and ethmoid operation first, and then at the second operation to begin the removal of bone at the hairline and work down. As getting ahead of the osteomyelitis is of paramount importance in these cases, the second procedure is theoretically the better.

Case 6: M. F., white, male, age 24 years, entered the Massachusetts Eye and Ear Infirmary on April 6, 1932, on the service of Dr. Garland. His chief complaints were pain and swelling over the right eye.

The patient stated that for several months he had had a slight postnasal and nasal discharge. Two weeks before admission, he developed a head cold with an increase in the amount of discharge. One week later he developed a severe throbbing right frontal headache. On the morning of the day he entered the hospital his right upper eyelid became red and swollen.

On examination the inferior and middle turbinates on both sides were found to be red and enlarged. Both nares contained a considerable amount of purulent secretion. The right upper eyelid was swollen, red and tender. His temperature was 100° and the white blood count was 10,200.

X-ray studies showed pus in both antra, the left ethmoid and the left frontal sinus. Considerable reaction was noted in the bone about the frontal sinus.

Daily shrinking of the nasal mucous membrane was instituted and the patient was almost entirely relieved of his pain. However, the swelling of the eyelid persisted. Further X-ray studies on April 14, 1932, demonstrated a slight increase in the reaction of the bone about the frontal sinus, so surgical intervention was decided upon.

On April 15, 1932, under ether anesthesia, Dr. Schall performed a right radical antrum operation and an external right frontal and ethmoid operation. All of these sinuses contained pus under pressure.

An orbital abscess was drained but there was no gross evidence of diseased bone.

The open wound continued to discharge a large amount of pus after this operation, but the patient's temperature remained normal until April 27, 1932, when it went up to 102°. X-rays on this date showed a definite osteomyelitis of the frontal bone extending two and one-half inches above the right frontal sinus.

The next day, April 28, 1932, Dr. Schall again operated on the patient. Incisions were made through the full length of both eyebrows and from these another incision was carried upward in the midline for about five inches. The flaps thus made were turned back to expose the frontal bone. The left frontal sinus was opened and thickened mucous membrane cleaned out. Trephine openings were then made one and one-half inches above the right frontal sinus. This bone was soft and pus oozed from the diploe. In attempting to get beyond the infected area a trephine opening was made two inches higher up. This bone was hard and apparently normal. A trough was made across both sides of the frontal bone at this level. The bone was separated from the dura and superior sagittal sinus and removed in one piece. The lower limit of removal was one inch above the frontal sinuses. As the bone was lifted off a large extradural abscess was uncovered just to the right of the midline. The patient's condition would not permit the removal of the remaining bone above the sinuses.

The patient was very much improved by this operation. His temperature returned to normal and remained so for over a month. By May 15, 1932, he was able to walk around the ward. Because of his improved condition further operation for removal of the bone remaining above the frontal sinuses was decided against.

However, on June 2, 1932, the patient's temperature began to rise, until by June 6, 1932, it had reached 103°. He complained of severe headaches.

X-rays taken at this time disclosed a marked osteomyelitis in the frontal bone directly above the right frontal sinus, but no extension upward beyond the operative defect.

On June 9, 1932, Dr. Mysel reopened the wound and cleaned out the granulations. The bone above the right frontal sinus was very soft and necrotic. All of this bone and much of that over the left frontal sinus was removed with rongeurs.

The patient was greatly relieved after this operation but his temperature ranged between 98° and 101° for the next two weeks. X-rays taken on June 27, 1932, showed infected bone remaining

over the outer angle of the right orbit. Also there was evidence of osteomyelitis in the bone for one inch above the operative defect on the left side.

On June 30, 1932, the vertical incision, previously made, was extended well back over the vertex. The remainder of the frontal bone and approximately the first inch of the parietals was outlined by trephine openings and removed in one large piece. Over the vertex at about the level of the frontoparietal suture an extradural abscess was uncovered. The diseased bone over the outer angle of the right orbit was then removed.

On July 13, 1932, 15 c.c. of thick pus was obtained from an abscess in the soft tissues over the vertex.

The eye consultant on July 16, 1932, reported as follows: "Both fundi show a papilloedema of two to three diopters. The veins are very tortuous and engorged. There are fresh linear hemorrhages above the left disc."

Brain abscess was considered because of the papilloedema and frontal headaches. However, there were no localizing signs and an exploration was not done.

On July 22, 1932, dressings consisting of 3 oz. of oatmeal and 60 gr. of potassium aluminum nitrate were started. The purpose of this dressing, which has been used in chronic osteomyelitis of the long bones, was to bring the infection to the surface and to aid sequestration. As a matter of fact, the discharge was considerably increased after using it.

However, X-rays on Aug. 4, 1932, showed osteomyelitis extending for one inch into the margin of the bone bordering the right and left limits of the operative defect. The papilloedema persisted though reduced to one and one-half diopters. He had very severe pain over the vertex and frequently large quantities of pus were evacuated from between the scalp and margins of the bone. Extradural and brain abscesses were feared but the patient refused further operation.

However, on Aug. 26, 1932, he consented and was operated on by Drs. Smyth and Mysel. The midline incision was carried posteriorly toward the occiput. After retracting the skin flaps and cleaning away granulations, the necrotic bone along the right margin of the defect was removed with a rongeur for about two inches. Necrotic bone was also removed from the vertex.

The surgical procedure was hurried and unsatisfactory because the patient's condition was so poor. A blood transfusion improved the pulse and blood pressure very slightly but not sufficiently to

permit completion of the operation. When the patient was returned to bed the pulse was barely perceptible. The patient died within an hour after operation.

Autopsy was limited to the obtaining of a few specimens and examining the structures *in situ*. While removing the necrotic bone in the midline toward the posterior parietal region a very large extradural abscess was uncovered. This abscess apparently extended back to near the occipital lobe. The dura was markedly thickened and covered with granulations. The brain tissue was edematous but no brain abscess could be found.

Pathological report; specimens from the first operation: The antral mucous membrane showed acute and chronic inflammation. The mucous membrane was thickened, edematous and densely infiltrated with polymorphonuclear leukocytes and lymphocytes. The glands showed cystic dilatation.

The mucous membrane from the right frontal sinus also showed acute and chronic inflammation. It was markedly edematous and infiltrated with plasma cells, lymphocytes and polymorphonuclear leukocytes. The blood vessels were dilated and congested but there was no evidence of thrombophlebitis.

Specimens from the second operation: The mucous membrane from the left frontal sinus was essentially similar to that previously taken from the right frontal sinus.

Bone from the anterior wall of the left frontal sinus was partially necrotic. In a few areas there was considerable lacunar absorption. The Haversian canals were empty but the bone structure was intact.

Bone from two inches above the right frontal sinus was necrotic and ragged. Bone cells were missing and resorption was marked. The bone structure was not distinct. A few of the medullary spaces contained pus; the others were empty. The periosteum over this area was markedly edematous. There was considerable diapedesis and the tissue contained a few polymorphonuclear leukocytes.

Bone from two inches above the left frontal sinus showed an early acute osteomyelitis. The bone structure was well preserved except for a few areas in which there was slight erosion. Most of the medullary spaces contained normal myeloid tissue but in a few of them there was a dense polymorphonuclear leukocytic infiltration. The periosteum covering this area was slightly but definitely edematous. There was no cellular infiltration, however.

Bone from three and one-half inches above the right frontal sinus was normal. The periosteum in this region showed a slight edema but no other abnormalities.

Bone from three and one-half inches above the left frontal sinus was normal.

Specimens from the third operation: Bone from just above the right frontal sinus was necrotic. Destruction had been quite marked with the formation of numerous small sequestrae. The myeloid tissue was degenerated.

Bone from above the left frontal sinus was necrotic and irregular. The periosteum was edematous, congested and densely infiltrated with pus cells.

Specimens from the fourth operation: A specimen from three and one-half inches above the left frontal sinus, where normal bone had previously been removed, revealed dead bone. There was considerable resorption and the myeloid tissue was degenerated. Many of the medullary spaces contained granulations.

Bone from the upper limits of bone removal on the right side was normal. The periosteum over this bone was markedly edematous but showed no inflammatory infiltration.

Bone from the left parietal bone, one inch beyond X-ray evidence of osteomyelitis, was partially necrotic but most of the normal structural arrangement of the bone had been retained. The myeloid tissue was infiltrated with polymorphonuclear leukocytes. The periosteum covering this bone was markedly edematous and showed a perivascular infiltration with round cells and a few polymorphonuclear leukocytes. A few areas of the tissue were very densely infiltrated with polymorphonuclear leukocytes.

Specimens obtained at the limited autopsy: Explorations for a brain abscess were negative. Specimens of bone removed from the margins of the operative defect, except for that high on the right side, all showed acute osteomyelitis. In most of these specimens, there was marked destruction.

A specimen of brain cortex from four and one-half inches above the left frontal sinus (under necrotic bone) showed a very narrow margin of edema along its surface. The pia mater was edematous and moderately infiltrated with round cells.

The dura at the same level (under necrotic bone) was edematous particularly along its outer surface, where there was also a dense infiltration with polymorphonuclear leukocytes. The vessels were engorged and surrounded by inflammatory cells.

COMMENT.

When the operation on the frontal, ethmoid and antrum was done, nine days after the patient's admission to the hospital, it was found that there was osteomyelitis of the walls of the frontal sinus. I

suspect that there was also osteomyelitis of the frontal bone. However, the hospital record does not state that there was the customary edema of the soft tissues of the forehead. For twelve days the patient's temperature remained normal, then began to rise. Accordingly, a second operation was done at which bone was removed from above downward to an inch above the frontal sinus; then the operation had to be stopped on account of the patient's condition. The patient did well for about a month and again his temperature rose. The X-ray at this time showed osteomyelitis just above the right frontal sinus. My feeling is, as I just said, that infection had been present at this point long before.

A month later, that is, two months after admission of the patient to the hospital, there was X-ray evidence of osteomyelitis over the outer angle of the right orbit and above the operative bone defect on the left. Consequently, the remainder of the frontal bone and the first inch of the parietal were outlined by drill holes and removed. This uncovered an extradural abscess at the vertex.

Thirteen days later, a scalp abscess over the vertex was opened.

Three more scalp abscesses appeared about an inch above and behind the superior margin of the bone defect. Under the use of oatmeal dressings, the pus worked forward and drained into the wound. The X-ray taken at this time showed an extension of the osteomyelitis for at least an inch beyond the upper limit of the operative wound.

Schilling makes the startling statement that in osteomyelitis, a scalp abscess always has an extradural abscess beneath it. My experience is not enough to corroborate this statement. I have a feeling, however, that this does occur often.

At the time these scalp abscesses were appearing, the records give the report of an eye consultation, which was as follows: "Both fundi show papilloedema of two to three diopters." With nearly the whole front half of the skull removed it was hard to see how there could be intracranial pressure. At autopsy multiple punctures did not find a brain abscess. There was, however, a large walled off extradural abscess beneath the posterior part of the parietal bone, and beyond the limit of bone removal. Therefore, in osteomyelitis of the skull, papilloedema should suggest not only brain abscess but the presence of an extradural abscess which is walled off and causing pressure.

In this case either the bone removal never got beyond the infection or there was repeated reinfection from the wound.

Case 7: F. P., white, male, age 39 years, was admitted on May 6, 1932, to the Massachusetts Eye and Ear Infirmary, complaining of

severe frontal headaches and a swelling over the right eye. Both symptoms were of four days' duration.

Two years previously, he had a head cold lasting for three months and accompanied by frontal headaches every morning. However, there was no nasal discharge. A similar condition developed six months later, lasting for about the same length of time.

There was no further trouble until three months previous to admission, at which time he began to have frequent mild frontal headaches. Four days before hospitalization, the headaches became much more severe and more constant. At the same time he noted a swelling over his right eye, which increased in size until it pressed against his glasses. These symptoms were accompanied by a profuse nasal discharge.

On examination, the middle turbinates were found to be enlarged, especially on the right side. The mucous membrane was red, congested and covered with a moderate amount of mucopurulent secretion. The tonsils were enlarged and infected. The soft tissues over the right frontal sinus were swollen, and tenderness was noted over the inner aspect of the right eyebrow. His temperature was 99° and the white blood count was 12,000.

X-ray examination disclosed an infection of the right frontal and ethmoid sinuses, without evidence of osteomyelitis.

On May 12, 1932 (six days after admission of the patient), under ether anesthesia, Dr. Evans did a right external frontal and ethmoid operation. The soft tissues were found to be markedly edematous. The nasofrontal duct was blocked by granulations. The bone of the anterior wall of the frontal sinus was softer than normal but not discolored. The frontal sinus was extensive laterally and over the orbit. There was an extension across the midline over the left frontal sinus. The sinus contained thickened mucous membrane, granulations and pus. The ethmoids were filled with polypoid mucous membrane and pus. The sinuses were cleaned out and the wound was left open.

The patient was considerably improved after this operation until May 23, 1932, at which time his temperature went up to 100° and his headache returned.

X-rays did not reveal any evidence of osteomyelitis.

However, on May 25, 1932, the old wound was enlarged by an incision extending across the midline to the left side. The anterior wall of the prolongation of the right frontal sinus over the left side was found to be softened. This was completely removed, as were also the granulations found in the prolongation. The posterior wall

of the sinus was intact and appeared normal except for one small area which was slightly whiter than the surrounding bone. However, it was not removed.

The headaches disappeared for three days when they again became severe. His temperature went up to 102° and the white blood count was 16,000. The neurological examination was negative.

X-rays on May 29, 1932, were negative for osteomyelitis. However, while dressing the wound the next day, it was noted that the bone immediately above the frontal sinus was slightly discolored.

On June 1, 1932, under ether anesthesia, an incision was made from the frontal sinuses upward in the midline for five inches. The two flaps thus made were turned back to expose the frontal bone. On removing the posterior wall of the right frontal sinus, thick pus was released from an extradural abscess. The bone just above the sinus was softer than normal. Trephine openings were made on the right side about four and one-half inches above the sinus and the bone was removed in one piece. Grossly the remaining bone appeared normal. The wound was left open.

There were no further symptoms until June 7, 1932, at which time he developed severe generalized headaches, and his temperature reached 101.6°. X-rays taken on June 6, 1932, were negative.

On June 8, 1932, the bone on the right side a short distance above the temporal bone was outlined by trephine openings and removed down to the supraorbital ridge. The condition of the patient made it necessary to stop the operation, although the bone along the temporal margin of the defect was believed to be diseased.

The patient was improved after this operation. However, X-rays on July 11, 1932, disclosed a definite osteomyelitis along the right margin beginning to involve the greater wing of the sphenoid.

On July 19, 1932, the remainder of the right supraorbital ridge was removed, also the right frontal bone back to and including a small area of the greater wing of the sphenoid.

Cultures taken from the frontal sinus and the diseased bone showed staphylococcus aureus. Cultures of the spinal fluid and blood taken at intervals during the patient's stay in the hospital were negative.

X-rays taken on July 22, 1932, showed a very small area of osteomyelitis in the margin of the greater wing of the sphenoid on the right side. The next day a blood transfusion was given, following which the patient was very markedly improved and was free from complaints.

X-rays on Aug. 2, 1932, showed no extension of the process found on July 22, 1932.

On Aug. 7, 1932, a small sequestrum was removed from the upper margin of the defect on the left side. One week later, a sequestrum the size of a dime came away with the dressing from the area in the greater wing of the sphenoid.

The patient rapidly improved after that time and was soon active. A plastic operation for removal of the extensive scar was done by Dr. Kazanjian on Nov. 5, 1932.

The patient still returns for observation but there has been no evidence of a recurrence of the disease.

Microscopic findings; specimens from first operation: The mucous membrane from the right frontal sinus was markedly thickened, edematous and infiltrated with lymphocytes and polymorphonuclear leukocytes. The epithelium was degenerated and the surface was covered with pus and fibrin. No thrombosed vessels were found.

The bone from the anterior wall of the right frontal sinus near the supraorbital ridge was necrotic in a few areas. In these areas there was considerable irregularity in the structure of the bone. Inflammatory infiltration, however, was very slight.

The bone from the upper limit of the anterior wall of the right frontal sinus appeared normal with no infiltration or destruction. The periosteum over this bone, however, was thickened, slightly edematous and moderately infiltrated with both lymphocytes and polymorphonuclear leukocytes.

Specimens from the second operation: The bone from the anterior wall of the right frontal sinus prolongation to the left side was definitely necrotic. The Haversian canals were partially filled with granulations and exudate, and contained small sequestra. There was considerable bone erosion in this area.

Specimens from the third operation: The bone from the posterior wall of the right frontal sinus was necrotic. Lacunar resorption was marked. New bone formation was found in this area.

Bone from the junction of the posterior sinus wall with the frontal bone consisted of small irregular spicules of necrotic and eroded bone. The myeloid tissue was degenerated but only slightly infiltrated with inflammatory cells. The periosteum over this bone was edematous, highly vascular and quite densely infiltrated with pus cells.

The bone from one inch above the right frontal sinus showed an acute osteomyelitic process. The medulla and many of the Haversian canals were filled with pus. There were many necrotic areas and destruction was quite marked.

Acute osteomyelitis was also found in bone specimens removed from two and one-half inches above the frontal sinus. The medul-

lary tissue was replaced by granulations and pus cells. The margins of the bone were irregular as a result of erosion and osteoclastic activity. Lacunar resorption was noted in a few areas.

The bone from the upper limit of the operative defect, *i. e.*, three and one-half inches above the right frontal sinus, appeared normal.

Specimens from the fourth operation: Bone from one and one-half inches above the left frontal sinus showed an acute osteomyelitis. Much of the bone was necrotic. The bone spaces were filled with granulations and pus cells, and numerous osteoclasts could be seen along the irregular margins of the bone. Septic thrombosis was found in several of the blood vessels.

The bone from two and one-half inches above the left frontal sinus showed quite a dense infiltration of the myeloid tissue with pus cells. Much of the bone appeared necrotic but there was no osteoporosis.

The bone from three and one-half inches above the sinus was normal.

Specimens from the fifth operation: The bone from above the outer angle of the right orbit was necrotic and irregular. Lacunar resorption was marked. The medullary spaces were filled with highly vascular granulations in which there were numerous small sequestra. There was considerable osteoclastic activity.

Acute osteomyelitis was found in the bone removed from the outer limits of the operative defect on the right side. The medulla was filled with pus and there was a moderate amount of erosion. The structure of the outer and inner tables, however, was intact.

Specimens from the sixth operation: A specimen taken from the frontal bone near the greater wing of the sphenoid showed the bone spaces to be filled with granulations. However, there was very little destruction.

The sequestra which were later recovered from the wound were necrotic and showed marked resorption. The bone spaces contained granulations.

COMMENT.

In the report of the specimens removed at the first operation, the following note occurs: "Bone from the upper limit of the anterior wall of the left frontal sinus appeared normal with no infiltration or destruction. The periosteum over this bone, however, was thickened, slightly edematous, and moderately infiltrated with lymphocytes and polymorphonuclear leukocytes." This note shows that the medulla of the bone in osteomyelitis may show no infection, whereas it may be present in the periosteum. The inference is that the infec-

tion may progress along the periosteum faster than through the medulla. The writer has had the feeling for some time that this is possible, and if it is possible, and happens often, it adds to the significance of the edema of the soft tissues.

At the first operation, the osteomyelitis had invaded the outer angle of the right orbit. Here the specimen showed acute osteomyelitis.

At the sixth operation, the specimen from the frontal bone near the greater wing of the sphenoid showed the medulla to be filled with granulations. After this operation, two small sequestra came away from the orbital wing of the sphenoidal bone. The X-ray since then has shown no osteomyelitis. The patient has had his plastic operation and been discharged from the hospital well.

A return of headache and a rise in temperature heralded in each instance the relighting and extension of the osteomyelitic process. The fact that there were considerable periods without temperature and pain indicate that after each operation the bone gradually became infected from the secretions in the bone wound. This is a possibility in all operated cases of osteomyelitis, and is one of the recognized causes of the extension of the disease. The only preventative is to keep the wound as clean as possible with appropriate dressings. A bacteriophage seemed to keep the wound clean in the first case, and oatmeal poultices did the same in the sixth.

GENERAL COMMENT.

In this series of seven cases, six were male and one female. Other observers have found the disease to occur more frequently in the female, with a ratio of about 11-4.

As concerns the age of the patients, our findings are practically identical with those of other observers. That is, young people are more frequently involved. The oldest patient in this series was 36 years of age. The others ranged between 14 and 24 years. This apparently substantiates the theory that the more vascular and more loosely arranged diploe of young individuals predisposes to infection and the rapid spread of osteomyelitis.

In all of the cases, the infecting organism was staphylococcus aureus.

Normal bone was reached in many of the cases at the first operation. However, reinfection of the margin of the bone frequently occurred, necessitating further operation. Apparently, then, organisms of low virulence can readily reinfect bone.

In this series the first two patients who died reached the hospital almost moribund. The third patient was in the hospital five months and died after the seventh operation.

In osteomyelitis of the frontal bone, it is only the initial edema which counts, because after the incision of the skin and the laying back of the flaps, there is always a certain amount of bogginess of the soft tissues about the edges of the bone defect. No significance, of course, can be attached to this. Also after a radical frontal sinus operation, it occasionally occurs that the cavity reinfects after months or years and the old incision becomes puffy and edematous. This is due to a partial or complete blocking of the opening into the nose, plus infection. The condition usually subsides after curetting into the sinus from the nose, or after opening the old scar, or in severe cases after using both procedures. Such cases usually are successfully managed in this way. The edema is generally pretty well confined to the front wall of the sinus. Only when it extends well onto the forehead is it of any value as a sign of beginning osteomyelitis.

The operation for osteomyelitis is bloody, and it is often better to do a partial operation and to finish it in a reasonable time rather than to continue and to drain the patient's vitality excessively. The bleeding from the bone is so constant, although not large in volume at any one time except when removing granulations, that the operator is liable to underestimate the amount of blood which the patient loses. It will be noticed that in a number of the cases where there were multiple operations, the patient's condition became poor and the operation was accordingly stopped. A one-stage operation is to be aimed at, but multiple operations at times are imperative, and success can follow them.

In order to prevent multiple operations if possible, it would be well to adopt the procedure used by Bailey, of Chicago; that is, a typed donor should be in readiness at the time of the operation. Then, if the patient's condition becomes poor, blood may be taken from the donor and put into the great or small saphenous vein at the patient's ankle. This requires about fifteen minutes. The surgeon may continue his work or stop until the transfusion is completed, as his judgment dictates. Generally he keeps on. Transfusion on the table (using the citrate method) has proved very efficient.

Furstenberg has the feeling that septic thrombosis of the veins of the mucous membrane of the frontal sinus is the cause of osteomyelitis of the frontal bone. At the time the writer saw him last, he did not have pathological specimens to prove this. The writer, however, has been more fortunate. In one of this series of seven cases in which the mucous membrane of the frontal sinus was mark-

edly infected, septic venous thrombi were found. This specimen is shown in Fig. 1. (Thrombosis in the bone of the same patient is shown in Fig. 8.) In dealing with osteomyelitis of the skull, it is most important that the operator should constantly be on the lookout for the presence of extradural abscess, subdural abscess, thrombosis of the superior longitudinal sinus, and of brain abscess. It is especially common to find an extradural abscess. If, on making an exploratory trephine opening in the frontal bone, pus is seen to well up in quantity from between the two layers of the bone (this occured in Case 1), the operator can be sure that he is dealing with an extradural abscess and should not be content in the removal of bone until the abscess has been completely uncovered.

Schilling makes the statement that in osteomyelitis of the skull, wherever there is an abscess of the scalp, there is also an extradural abscess at the same point. Evidently he has cases which warrant this very positive statement. The writer's experience is too limited to justify his making a statement as positive as this. However, the great point that in osteomyelitis of the skull the operator should expect extradural and subdural abscess cannot be borne too strongly in mind.

The danger of opening the superior longitudinal sinus when bone has to be removed across the midline naturally worries the operator at first. Experience has shown that the sinus separates readily from the skull, the same as the dura.

The writer believes that the superior longitudinal sinus is often infected, if not thrombosed, in osteomyelitis of the skull, because many veins from the dura and the pia run into it. The time is coming when this sinus will be opened on suspicion the same as we now open the lateral sinus. As the sinus is laid bare for two to four inches by the customary removal of bone, exploring it is easy.

I have already expressed my indebtedness to Furstenberg. I wish at this place to touch on a few points which appeared in his paper. He suggested that osteomyelitis may be limited by the sutures of the skull. Fig. 15 shows that a suture in the adult is only a partial barrier. In this specimen, the medulla of the bone is not interrupted. He further stressed the point that early and repeated operations are necessary. The writer, of course, agrees to this heartily. The earlier the better, and the operator's aim should be a single operation where possible. In operating Furstenberg removes the bone from the diseased area outward and has had splendid success. Nevertheless, the writer feels that it is more surgical to begin with normal bone, that is, at or near the hairline and work downward into the diseased bone.

In secondary operations or when the patient's condition is poor, this rule does not hold. The operator has to get ahead as fast as he can and naturally starts with the necrotic area. Furstenberg's beautiful case in which the whole calvarium was finally restored probably has never been duplicated. It is a great comfort to other operators to know that even the most extensive removal of bone is repaired by Nature.

In long continued cases of osteomyelitis the infection has a tendency to spread laterally into the external angular process of the frontal bone and backward over the roof of the orbit. Osteomyelitis does not spread easily in compact bone such as the roof of the orbit. In such places it tends to localize and to form sequestra. Nevertheless, extension backward over the roof of the orbit does occur frequently and is a deadly complication because meningitis so often supervenes. The fact that osteomyelitis has a tendency to extend laterally in the frontal bone calls for a generous removal of bone in this locality. In Case 6 the extension was outward into the external angular process of the frontal bone, and in Case 7 backward over the roof of the orbit into the orbital face of the sphenoidal bone. In the latter case sequestra formed and were extruded. The patient finally recovered.

An exploratory trephine opening is of great value. The operator can use it freely anywhere except, of course, over the superior longitudinal sinus. The trephine opening often shows pus in the diploe and at once tells the operator that he should go higher. It may even evacuate an extradural abscess, especially if it is made near the frontal sinus.

The two major points brought out by the analysis of the seven cases are as follows:

The first point has to do with the extent of the infection in the medulla of the bone when there is actual necrosis. The microscopic sections have proved that if the X-ray shows bone necrosis, the medulla of the surrounding bone is infected for an inch to two inches beyond the area of necrosis. The practical application of this is obvious.

The second point has to do with the significance of edema. It is the general opinion that the X-ray shows the beginning of osteomyelitis, and physicians are accustomed to wait for X-ray confirmation of osteomyelitis before operating. The writers of this paper have proved to their satisfaction that edema is the first sign and that the X-ray is not positive until seven to ten days later. The X-ray shows only necrotic bone, not infected bone. Edema means infection of the

medulla of the bone, and of the periosteum and they run a parallel course. The extent of the edema has been proven to be a practical guide to the limit of the infection of the medulla. That the X-ray lags behind the edema by a week or more before it gives positive signs is a point which cannot be too strongly emphasized.

THE EMBRYOLOGY AND HISTOLOGY OF BONE.

Before beginning the pathological discussion of osteomyelitis of the skull, a brief review of the embryology and histology of bone will be given. Because of the physical peculiarities of bone, it is almost

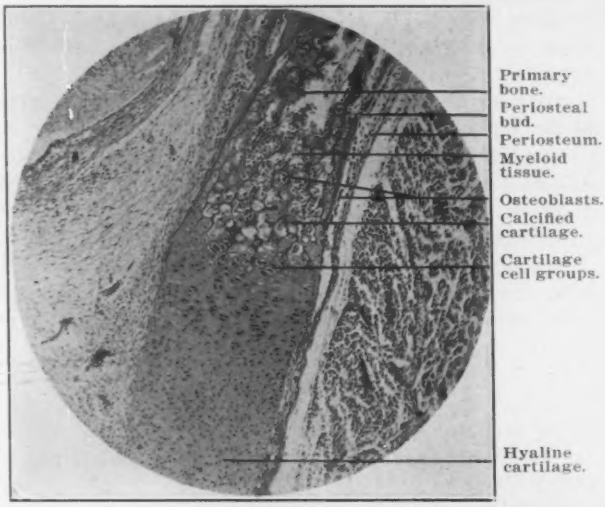

Fig. 12. This section shows endochondral ossification. Degeneration of the cartilage cells leaves irregular spicules of calcified cartilage. Primary myeloid tissue, from which osteoblasts are derived, is given off from the periosteal bud. Osteoblasts begin the deposition of the first true bone upon the spicules of calcified cartilage.

impossible to understand the changes it may undergo under the influence of an infection, unless one bears in mind the way in which this dense and solid structure is formed, dissolved and reformed in the processes of development and growth. Inflammation in bone is fundamentally dependent upon the same general conditions and presents essentially the same series of phenomena as inflammation in other types of connective tissue. However, the manifestations of the disease may be modified and often obscured not only by the

hardness of the tissue but also by the frequent participation in the process of specialized connective tissue cells which produce and destroy the basement substance. These cells, namely the osteoblasts and osteoclasts, work together with the infectious process to produce the alterations in the basement substance, which give the pathological picture its essential characteristics.

The activity of these cells, the nature of the bone medulla and the structure of the basement substance may best be observed in embryonic bone.

Fig. 12 is cut through a vertebra of a pig embryo and shows endochondral ossification. Toward the periphery is seen typical hyaline cartilage with its characteristic isogenous cell groups. This tissue grows by mitosis of its cells and the production of new interstitial substance. Toward the central portion the cells are seen to multiply in a special fashion; that is, the planes of division are perpendicular to the long axis of the bone. As a result, instead of rounded isogenous cell groups, axial groups are formed in the direction of the long axis of the bone. Cells are separated from others of the same group by just a thin matrix while considerable interstitial substance remains between adjacent groups. The cells in this region now undergo degeneration with the formation of vacules which contain mineral salts, chiefly calcium phosphate. These salts escape into the interstitial substance, forming calcified cartilage. Into this area now extends the embryonic bone marrow derived from the periosteal bud and carrying loops of blood vessels. The histiolytic ferments of the cells in this tissue destroy the calcified cartilage, following the line of least resistance through the cartilage cell-columns and leaving irregular spicules of calcified interstitial substance. The connective tissue cells lying against the spicules immediately assume a pyramidal or cuboidal shape and are transformed into osteoblasts. These cells then begin the deposition of the first true bone upon the spicules of calcified cartilage. If they cease to function they are enclosed in the bone matrix formed by their neighbors and are now called osteocytes.

In intramembranous ossification, the osteoblasts are derived from the mesenchymal or young connective tissue cells. These begin the deposition of true bone directly in the connective tissue.

In either endochondral or intramembranous ossification, as soon as the first true bone appears, the digestive process, which is a function of the osteoclasts, begins. As new bone is formed by the osteoblasts, the older bone is removed by the osteoclasts. In this way the bone increases in size with the growth of the embryo or child,

and assumes the definite form of the adult bone. Fig. 13 illustrates this action of the two specialized cells.

It is cut through the mandible of a pig embryo and demonstrates intramembranous ossification. One surface of the bone spicules is lined with osteoblasts, while along the opposite side there are numerous osteoclasts. Thus the bone is being deposited and destroyed in the same direction, for the purpose of enlarging the tooth socket.

Haversian systems replace the primary lamellar arrangement of both types of bone, to give strength and sufficient nutrition to all areas. To form these systems, the osteoclasts eat their way, so to speak, into the primary bone. Into the opening thus produced extends the embryonic tissue of the bone marrow, carrying with it

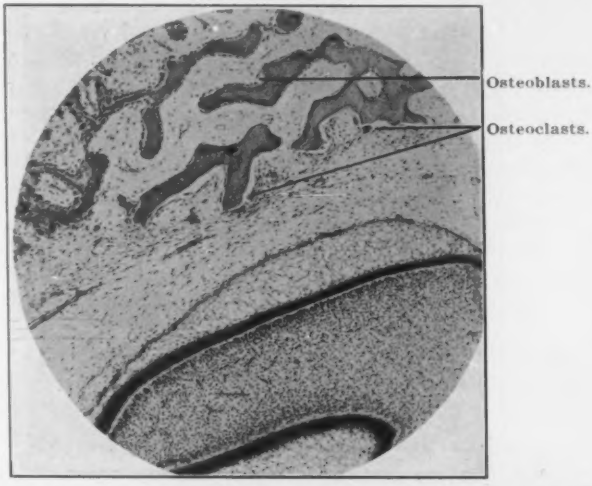

Fig. 13. This section shows intramembranous ossification. The side of the primary bone spicules away from the tooth anlage is lined by osteoblasts. Osteoclasts are present along the opposite surface of the bone. The bone is being formed and destroyed in the same direction, i. e., away from the tooth anlage, for the purpose of enlarging the tooth socket.

central blood vessels. Osteoblasts then fill in the opening with concentric lamellae of bone down to the blood vessels. The channel in which the blood vessels now lie is known as an Haversian canal. Each canal connects with the lacunae of the adjacent area, in which the bone cells or osteocytes lie, by a series of small canaliculi. The canal, together with the canaliculi and lacunae, constitutes an Haversian system.

In the flat bones of the skull, the compact bone of the outer and inner tables is composed of Haversian systems. The diploe between these two tables consists of cancellous bone filled with myeloid tissue. This myeloid tissue (see Fig. 14) or marrow is of the "red" variety. It consists of a reticular tissue framework, in the meshes of which are found fat cells and the myeloid elements, namely, giant cells or megakaryocytes, premyelocytes, erythroblasts, lymphocytes, and mature corpuscles, both red and white. The presence of these cells makes differentiation between normal bone marrow and an early inflammatory infiltration into the marrow somewhat difficult.

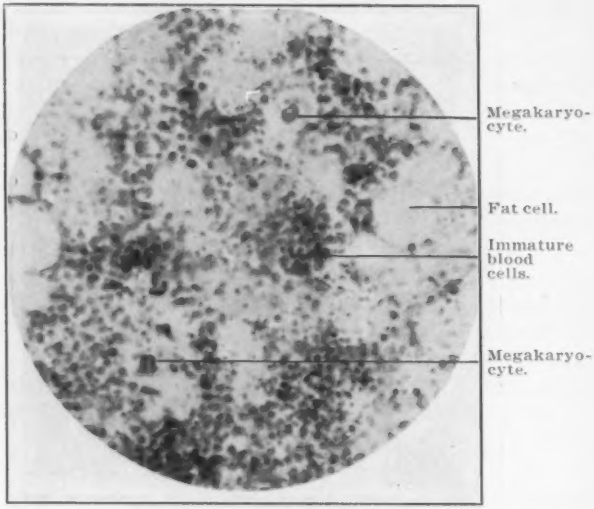

Fig. 14. This section shows normal myeloid tissue which consists of a reticular tissue framework in the meshes of which are found fat cells, megakaryocytes and immature blood cells.

The blood vessels of the myeloid tissue, Haversian canals, periosteum and dura, connect freely with one another.

The walls of the frontal sinuses are composed of compact bone. The outer walls correspond to the external plate of the frontal bone and the inner walls are continuous with the internal table. In serial sagittal sections of fifty skulls, Furstenberg found that "in most instances frontal sinuses, both large and small, are completely surrounded by a layer of compact bone, while in others there is an abundance of spongy tissue in both the anterior and posterior walls

of the sinuses in close proximity to the lining mucous membrane." In any case the vascular supply of the mucous membrane of the frontal sinuses is more or less closely connected with the vessels of the periosteum, dura and frontal bone.

THE PATHWAYS OF INFECTION.

This brings us to a consideration of the pathways by which infection can pass from the frontal sinuses into the frontal bone. Unfortunately, statements concerning the mode of infection are necessarily assumptions, because the insidious onset of the disease, and the difficulty in diagnosing it in the very early stages, prevents the securing of specimens of the lesion at the time when the transmission of the infection to the bone tissue actually occurs. However, the anatomical points just mentioned reveal two possibilities.

First, the direct extension of infection from the mucous membrane to the underlying bony walls of the frontal sinuses, and from there to the calvarium. If there happened to be spongy bone in the anterior and posterior walls, in close proximity to the membrane, the infection would readily be transmitted upward through the myeloid tissue to the diploe of the frontal bone. However, as McKenzie has shown, spongy bone is not necessary for the spread of osteomyelitis. The spread of the disease through the thin hard bones of the ethmoid, lacrimal, nasal and orbital bones is sufficient proof for this statement. If then, the walls of the frontal sinuses are composed of compact bone, it is entirely possible that the infection could travel through the Haversian systems to reach the calvarium.

Secondly, transmission of the infection may take place through vascular channels. From a focal thrombophlebitis in the mucous membrane, the infection could be carried by retrograde thrombosis, through the vessels of the dura, periosteum and Haversian canals to those of the diploe. In the first case of our series, thrombophlebitis was found in both the mucous membrane of the frontal sinus and the diploe of the frontal bone (see Figs. 1 and 8). In other cases, thrombosed vessels were found in the diploe but not in the mucous membrane. The writers are of the opinion that the first case, if not others, is an example of infection traveling by retrograde thrombosis.

In the literature considerable evidence has been advanced to substantiate both theories and in all probability infection is carried through either or both of these routes.

The frequent occurrence of osteomyelitis of the frontal bone following operations on the frontal sinuses is alarming. It apparently makes little difference whether the operation is extensive or of minor

proportions. Also it may follow operations for chronic as well as acute sinusitis. Operative trauma, though it cannot be avoided, does expose raw surfaces of bone to direct invasion by micro-organisms.

Once infection has reached the diploe through one channel or another, the conditions favoring extension are loose structure of the marrow and its rich venous supply. The first condition depends upon the age of the patient. As Schilling points out, there is an atrophy and shrinkage of the diploe and a corresponding increase in bony solidity as age advances. This, of course, would lessen the

Fig. 15. This section shows the frontoparietal suture of a man 32 years of age. The periosteum is continued along the surface of the bones and does not extend down between them. The diploe of the two bones are continuous across the suture.

ease with which infection could travel through the bone and probably accounts for the fact that most cases of spreading osteomyelitis occur in young individuals. The rich venous supply of the diploe would also favor a rapid transmission of the infection. Furstenberg states that the finding of thrombophlebitis in advance of bone suppuration is not infrequent. In all of our cases, however, there was a generalized spread of infection through the medullary tissue. The fact that we did not find thrombosis ahead of suppuration does not negativate Furstenberg's findings, but rather, it adds to the assumption that both methods of spread are possible. Certainly, as he says, the

occurrence of isolated areas of osteomyelitis in the cranial bones is best explained by hematogenous dissemination of infection.

Osteomyelitis, most generally, is first noted just above the frontal sinuses, and from that point it spreads upward and laterally toward the parietal and temporal bones. The suture lines may act as a barrier to the progressive infection, but it is certainly not very effective. As McKenzie and others have pointed out, in adult life (see Fig. 15) there is a direct continuity of osseous structure between the con-

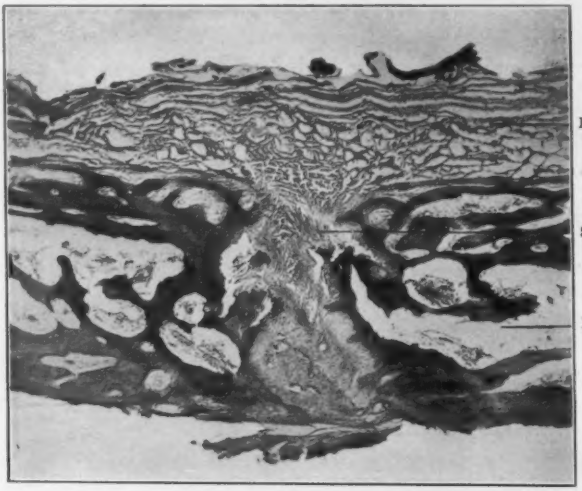

Fig. 16. This section shows the frontoparietal suture of a child 14 months old. The diploe of the two bones are separated by a thick fibrous membrane. This tissue is a continuation of the periosteum and dura into the suture.

tiguous bones of the skull. When the sutures are united, the diploetic veins communicate with each other and increase in size. The sutures would then act best as barriers to the disease in young individuals where the periosteum and dura extend between the bones (see Fig. 16), but even in these cases the infection can spread from one bone to another through vascular channels. It is well known that if a spreading osteomyelitis of the skull is left untreated, it will advance until either the patient dies or the whole vault of the cranium is necrosed.

GROSS AND MICROSCOPIC PATHOLOGY.

Our observations can add but little to the detailed descriptions of the gross appearance of infected bone as given by Wilensky and other writers. However, repetition is necessary for the sake of completeness and for a better understanding of the microscopic findings.

The gross appearance of infected bone naturally varies considerably with the stage of the disease. In the very early stages of osteomyelitis of the cranial bones, the diploe may show some congestion

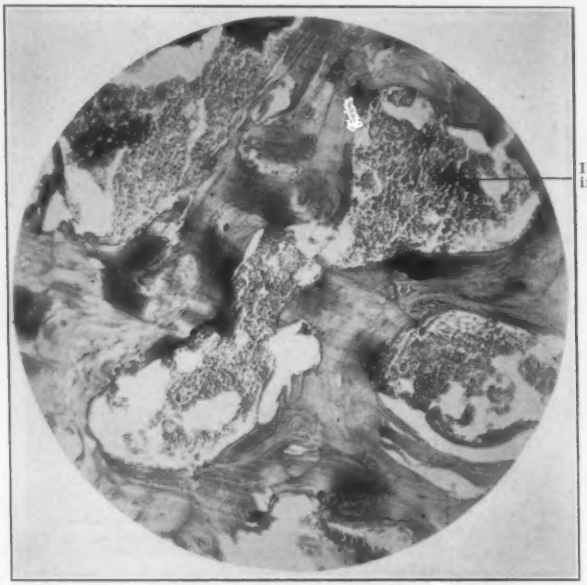

Fig. 17. This section shows an early infection in the diploe of the frontal bone. The myeloid tissue is infiltrated with lymphocytes and polymorphonuclear leukocytes. However, the bone structure is intact and its margins are smooth.

on cut section but generally no abnormality of the bone structure can be seen. Soon, however, the diploe become markedly hyperemic and contain small drops of pus. The bone appears slightly whiter than normal and its consistency is softened. After seven to ten days, the diploetic spaces are filled with granulation tissue, bathed in pus, which escapes freely from the cut surface of the bone. Thrombosed vessels may or may not be found. The bone itself becomes discolored, at first appearing hemorrhagic but finally becoming dark

red in color. As the disease progresses still further, pus may be seen oozing to the surface of the discolored bone through the vascular channels or through small eroded fistular openings. On removing the outer table small sequestra may be found in the diploetic spaces. Finally the infection breaks down the resisting external and internal tables with more or less widespread destruction, marked by collections of pus on the surface of the bone and irregular sequestration of either table.

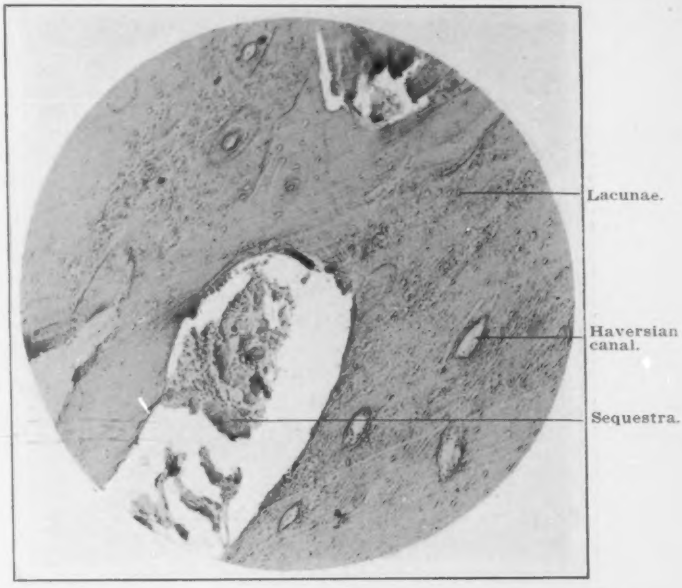

Fig. 18. Early bone necrosis is shown in this section. The lacunae are empty, and enlarged by resorption. The contents of the Haversian canals are degenerated. There is no myeloid tissue in the bone space which contains small sequestra.

Microscopic examination of specimens of bone in the very early stages of the disease (see Fig. 17) show the myeloid tissue to be somewhat edematous, with a congestion of the vessels. There is a moderate infiltration with lymphocytes and polymorphonuclear leukocytes but the bone structure is intact and its margins are smooth. The number of inflammatory cells rapidly increases especially around the blood vessels. Should the infection be blood born, some of the vessels will show septic thrombosis. A few areas will now be found

here and there, where the bone cells, or osteocytes, are missing and the lacunae are enlarged by resorption (see Fig. 18). Such necrotic areas are produced by an obstruction to their blood supply by the inflammatory process. As the infection progresses, the myeloid tissue becomes degenerated (see Fig. 19) and is replaced by granulation tissue and pus. Small chips of necrotic bone are sequestrated and lie free in the granulations. The margins of the bone lining the diploe are eroded and very irregular, giving a moth eaten appearance.

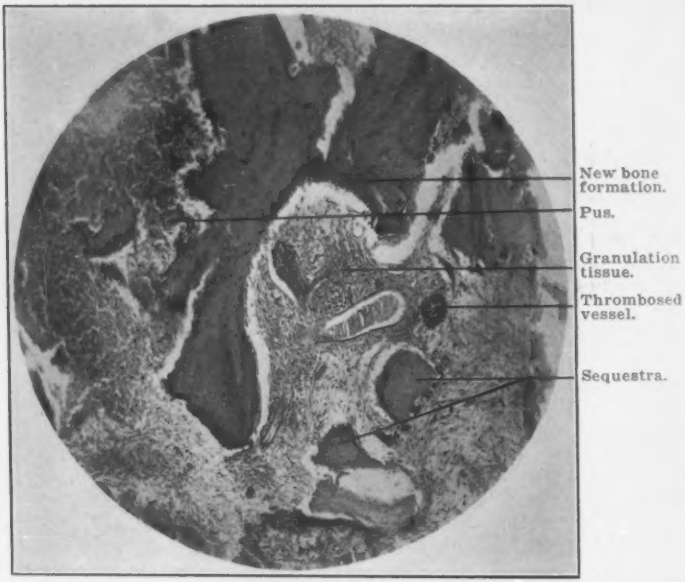

Fig. 19. This section shows the myeloid tissue of the diploe to be replaced by granulation tissue and pus. Small sequestra of necrotic bone lie in the granulations. The margins of the bone are eroded and irregular. In one area new bone formation is taking place. One of the blood vessels is thrombosed.

Osteoclasts appear surrounding the sequestra and lining up against the surface of the bone (see Figs. 20 and 21). To all appearances, the activity of these cells consists in further erosion and destruction of the bone. The number of osteoclasts varies considerably in different cases. Occasionally they are difficult to find; again they may lie side by side along the whole margin of the bone.

Frequently evidences of osseous repair can be found in the areas of destruction. It is not uncommon to find small areas of new-formed lamellae, lined by osteoblasts (see Figs. 19 and 22), in specimens that show marked destruction. Bone formation and bone destruction are present at the same time in diseased bone just as in embryonic bone. In the former case, however, the regressive changes predominate until the infected bone has been removed surgically.

Bone will attempt to raise a barrier against infection just as soft tissues will. Occasionally toward the periphery of the disease, the

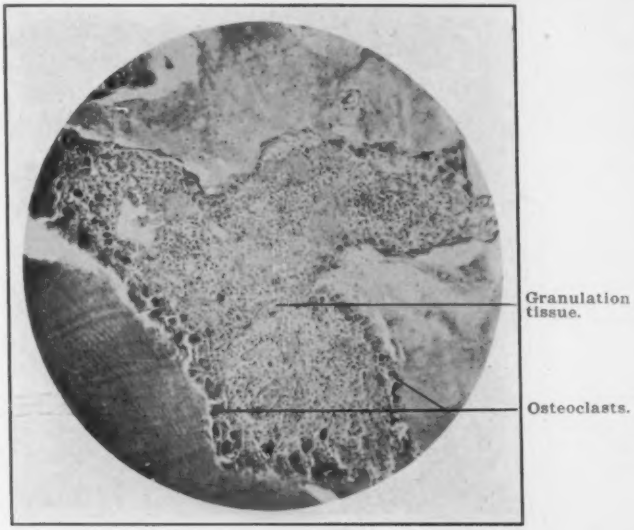

Fig. 20. This section demonstrates osteoclastic activity. A large number of osteoclasts can be seen along the margin of the bone. Granulation tissue has replaced the myeloid tissue.

granulations will be converted into connective tissue. This change, however, generally does not become sufficiently completed to arrest the progress of the disease.

The infiltration and pus formation spreads from the diploe, through the Haversian canals (see Fig. 23), bringing destruction to the compact bone. The destruction is chiefly by erosion, absorption, and sequestration. The amount of destruction depends upon the severity and duration of the disease.

The various stages of the disease may be studied by examining different areas of the frontal bone after it has become definitely infected. If osteomyelitis begins just above the frontal sinuses and has progressed sufficiently so that the X-rays will show it in that area, microscopic examination will demonstrate considerable destruction, and the diploe will be filled with granulations and pus. Progressing upward from this point the destruction and infiltration will gradually become decreased. Infiltration will be found generally for one to two inches in advance of the bone destruction. Hence,

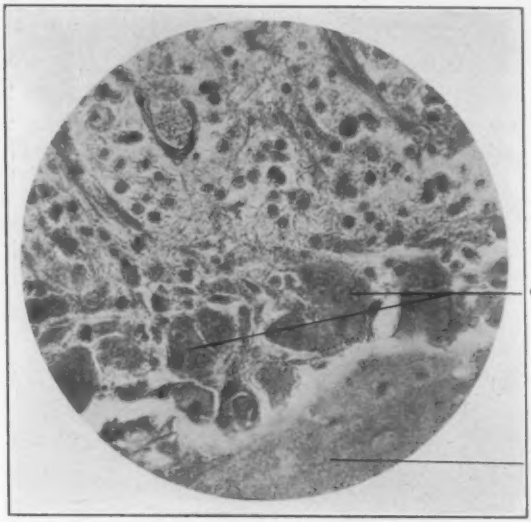

Fig. 21. This section is a high power view of osteoclasts. They are destroying the necrotic bone.

it is obvious that X-ray findings fall at least an inch short of the limits of the infection.

The infection is seldom limited to the bone but generally progresses along the dura, periosteum and soft tissues of scalp at nearly the same rate.

The dura mater is always affected (see Fig. 24), at first showing slight inflammation. Later it becomes thickened and granular throughout the entire extent of the lesion in the bones. The granulation tissue formed upon it may be very thick. When the infection breaks through the inner table an extradural abscess is formed, which

rapidly tends to organize. Furstenberg believes such an abscess exerts a destructive influence upon the inner table of the bone. According to him, "It is quite probable that this pathologic change upon the dura is in no small measure responsible for further extension of the infection. It often appears to develop in advance of the necrotic bone and to separate the dura from the cranial vault ahead of the osseous infection. Such an exudate between dura and

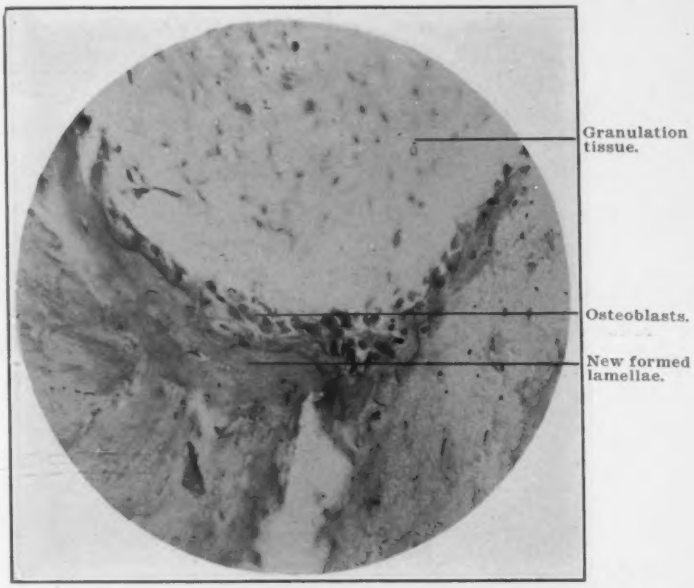

Fig. 22. This area of new bone formation was taken from a specimen of bone in which there was marked destruction. The section shows new-formed lamellae lined by many osteoblasts.

skull tends to cut off the chief blood supply of the cranial bones and thereby deprives them of adequate nutrition. Likewise, it would tend to favor the formation of septic thrombi within the intracranial diploic veins which it surrounds as it advances on the external surface of the dura."

In our cases, however, the extradural abscesses did not extend beyond the infected bone. Osseous destruction or infection was found in all instances over and beyond the limits of the extradural abscess.

The dura is able to withstand the infection for a considerable time but finally the infection breaks through, producing a meningitis or brain abscess.

At a point where bone changes are very early, with only congestion and slight infiltration of the myeloid tissue, the periosteum at the same level is edematous (see Fig. 25) and may or may not show slight infiltration. Its vessels become congested and as the bone dis-

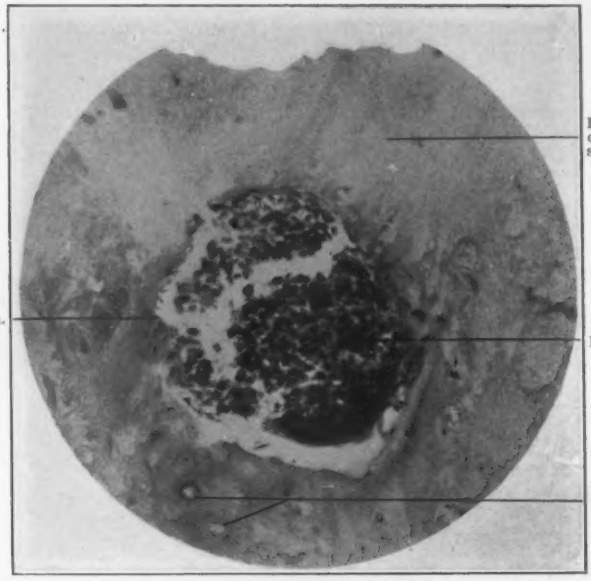

Fig. 23. This section shows an Haversian canal near the surface of the external table of the frontal bone. It is completely filled with pus cells which have replaced its normal contents. The bone shows erosion and resorption of the inorganic material. The lacunae are empty and enlarged and the normal lamellar arrangement of the bone structure is indistinct.

ease progresses it becomes definitely infiltrated (see Fig. 26). When the infection breaks through the outer table, a subperiosteal abscess is formed, stripping the periosteum up from the bone. The infection finally breaks through the periosteum, giving rise to an abscess in the soft tissues of the scalp.

The most important points, from the standpoint of the surgery of osteomyelitis, which were brought out by this microscopic study are,

that infection in the diploe of the flat bones of the skull extends to near the limits of the edema of the scalp and for one to two inches beyond the limits of the process as shown by the X-ray. Because of these findings, together with the clinical studies, the writers believe that edema of the soft tissues of the scalp offers the best indication as to the extent of bone removal necessary to get beyond the osteomyelitic process.

OPERATION.

On the question of operation, Mackenzie is the most direct and to the point, as well as the most convincing of the many writers on

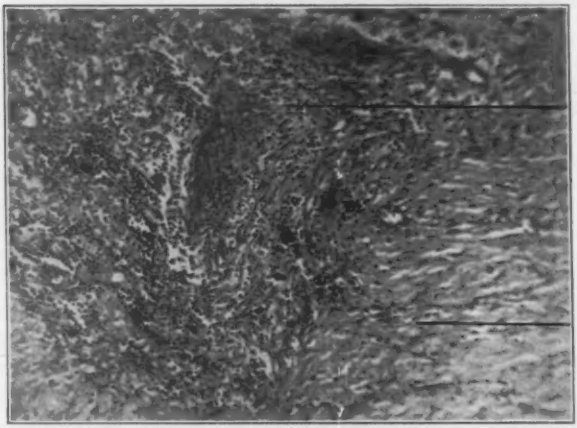

Fig. 24. This section of dura which covered the inner surface of eroded bone is edematous and quite densely infiltrated with inflammatory cells.

osteomyelitis of the skull. The following quotation is written in his usual forceful manner and summarizes some of the best thinking on this subject:

"Once osteomyelitis has set in, the only chance of saving the patient lies in the immediate and entire removal of the diseased bone. The whole thickness of the bone cranium must be removed down to the dura. Further, the superficial area of the bone resected must exceed the obvious limits of the disease. Intervention must be comprehensive; resection must be radical. In doubtful areas, it is safer to remove bone than leave it, so that removal should be carried wide of the disease in all cases. The sacrifice of large sections of the

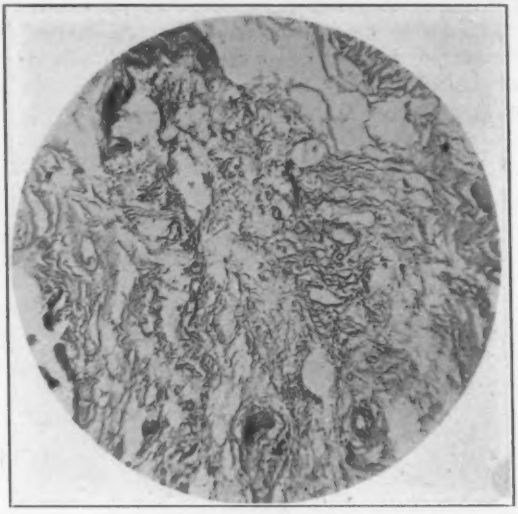

Fig. 25. This section shows edematous periosteum. It was taken from an area near the limits of the edema of the scalp. The underlying bone showed only vascular congestion and slight infiltration.

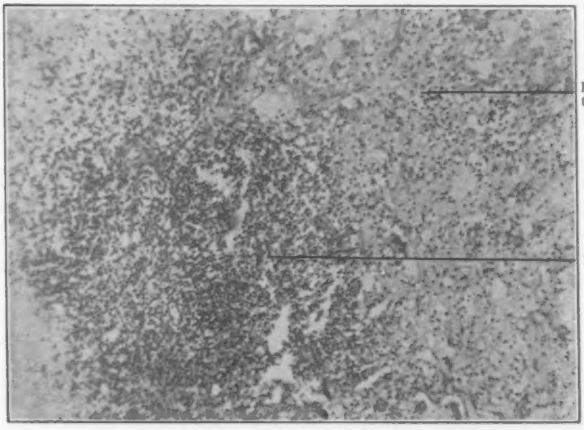

Fig. 26. The periosteum shown in this section covered necrotic and eroded bone. It is edematous and densely infiltrated with polymorphonuclear leukocytes.

bony cranium need arouse no apprehension for if the case recovers, the defect will be made good by osseous regeneration."

In this quotation, Mackenzie states that the operation should go beyond the "obvious limit of the disease," but does not say what the obvious limit is. From the microscopic study of the bone specimens removed in the seven cases of osteomyelitis here reported, the writers believe that the most obvious limit of the disease, as far as anything can be called obvious in this dreadful condition, is the upper limit of the edema. They feel that this point is a rough but practical guide to the extent of the infection of the medulla. In only one doubtful case of the seven has infection been found microscopically to extend beyond. Therefore, except beyond the limits of the edema, the operator should not expect normal bone.

Two main points stand out in connection with the operation for osteomyelitis of the frontal bone; namely, the first operation offers the greatest chance of success; infection of the medulla of the bone extends from an inch to two inches beyond any grossly necrotic area, so that the margin of safety is two inches above such an area.

The attitude of the surgeon in approaching an operation for osteomyelitis of the frontal bone should be that it is a case of "now or never," as the chances of success decrease with each secondary operation. Due to sepsis, the patient is constantly losing vitality and the longer a case lasts the greater is the chance of extradural and subdural abscesses—and they may be placed far away from the operative field, forming insidiously. Further, the longer a case lasts, the greater is the danger of a brain abscess. The surgeon, therefore, must almost at all costs get to normal bone at the first operation, and if possible make the first operation the final operation.

From the above statement, it follows that if there is frank edema of the soft tissues of the forehead, the skin incision should start beyond the limits of the edema and at least at the hairline and be carried down in the center of the forehead to the root of the nose. This is joined by a lateral incision slightly above and paralleling the eyebrow for its full length. If the X-ray shows that the mucous membrane of both frontal sinuses is infected, a similar horizontal incision should be made over the opposite eyebrow, and the whole forehead exposed by turning both skin flaps upward and outward and suturing them to the scalp.

The writer prefers the midline incision and the reflection of two triangular skin flaps rather than the curved incision of Mackenzie from temporal line to temporal line, because the flaps give better control of the frontal sinuses as they obliterate by granulations, and

the drainage and the dressing of the operative field are more easily and effectively carried out. The price of adequate drainage, as is so often the case in full surgery, is scar.

Suppose, however, only one frontal sinus is infected—for instance, the left—in this case the bone of the left half of the forehead and both the front and posterior wall of the frontal sinus are to be removed. In order to accomplish this, a roughly triangular area of bone, the lower limit of which is the upper limit of the frontal sinus, is marked out with trephine or burr holes about one-half-inch apart. The bone bridges between the openings are taken down with chisel, rongeur or DeVilbiss forceps. If the operator is proficient in the use of the Gigli saw, the bone to be removed is more quickly isolated. The bone openings are placed far enough to the right of the midline so as to miss the longitudinal sinus and to uncover it when the bone is removed.

Suppose both frontal sinuses are infected. Then the bone of both sides of the forehead from the limit of the edema down should be removed. The bone is removed in one piece, after previously isolating it.

It is easier than is usually supposed to separate the superior longitudinal sinus from the skull. It was readily accomplished in the seven cases here reported. The sinus has its origin at the foramen caecum; that is, at the upper limit of the frontal sinus, and here is a cord-like affair. Its separation, therefore, is, when possible, best begun at this point.

Osteomyelitis has a fashion of extending laterally into the external angular process of the frontal bone and sometimes into the temporal fossa. It is well, therefore, in isolating the plate of bone to be removed to go well laterally. When the plate of bone is free, it is removed by separating it from the dura from above downward. When this has been accomplished, both the anterior and posterior walls of the frontal sinus are then removed. This completes the operation. The skin flaps are left sutured to the scalp. The writer is strongly of the opinion that it is better in all cases to open and obliterate both frontal sinuses.

If there is necrotic bone just above the frontal sinus or in the anterior wall of the sinus itself, it is tempting to begin the bone removal at the necrotic area and to work upward and outward. Furstenberg does this and has been very successful in his results. However, the writer feels that the best surgical procedure is to work from normal bone to diseased bone. If this plan should not be followed, the operator should remember to change to sterile instruments when he is nearing normal bone.

In every operation for osteomyelitis of the skull, a donor for transfusion should be ready in case the patient stands the operation poorly. With the donor at hand, transfusion can be done on the table.

In secondary operations, it is not so easy to be systematic. The aim of all secondary operations, however, should be to remove a plate of bone sufficiently large so that its outer margins are at least two inches away from the necrotic area. Patients stand secondary operations relatively poorly, the operator has a sense of hurry, and the operation often resolves itself in the hasty biting out of what bone the operator can get at quickly. This means that it is generally a question in secondary operations of working from the diseased area outward. In secondary operations, also, it is even more true than in the primary operation that the operator should be constantly on the watch for extra- or subdural abscesses.

AFTER CARE.

Every effort should be made to keep the operative wound clean in order to prevent reinfection of the bone. Each operator has his own idea as to how this is best accomplished. Of late, some operators are turning to bacteriophage dressings. More thought should be put on this part of the operation, and it should be watched more carefully than is usually the case.

CONCLUSIONS.

In osteomyelitis complicating infection of the frontal sinus edema of the skin and soft tissues of the forehead is the first sign of infection of the medulla of the bone and of the periosteum. The infection of the myeloid tissue of the bone and of the periosteum occur at the same time, and advance together. The edema of the skin of the forehead is a practical guide to the extent of bone to be removed. This has been proved by the microscopical examination of bone specimens removed at operation. In operating, two large triangular skin flaps give the best exposure and the best drainage. The bone removal should begin beyond the edema, generally at or near the hairline, and be carried downward from normal bone to diseased bone. The X-ray does not give positive findings until necrosis occurs, and therefore is not positive until seven to ten days after the edema has shown infection of the medulla. When the X-ray finally is positive the infection of the medulla of the bone has extended from an inch to two inches beyond the necrotic area. Radical operation—multiple radical operations if necessary—offer the best chance of success.

These conclusions may be summarized as follows: Operate early and thoroughly; that is, radically. Don't waste a week waiting for a positive X-ray. Begin the removal of bone above the edema. Work down, not up; that is, from normal bone to diseased bone. Remember that osteomyelitis writes across the patient's brow not only the diagnosis but the treatment. Let the surgeon carry out this treatment. He will then get his best results.

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CIRCUMSCRIBED ARACHNOID CYST GIVING SYMPTOMS OF AN ACOUSTIC NEUROMA.

Dr. William V. Mullin, Cleveland.

Recently two patients, who, at operation were proven to have cystic tumors of the arachnoid, were studied at the Cleveland Clinic. In one case, the diagnosis before operation was probable acoustic tumor; however, the histories and otologic examinations in these two cases were atypical in some respects for this type of tumor.

A review of these two cases and of others in the literature has raised the question in my mind as to whether it might be possible to make before operation a diagnosis of cyst of the arachnoid from the history and a complete and thorough examination including that of the ears. From a correlation of the data to be found in the literature at the present time one can obtain no criteria upon which such a differential diagnosis might be based. It is an interesting fact that in only one case reviewed in the literature is there any record of a complete functional otologic examination before operation.

All who have written upon this subject are agreed that the condition of arachnoid cyst or tumor is likely to cause diagnostic confusion. To quote Harvey Cushing: "Chronic serous arachnoiditis or meningitis serosa circumscripta is above all other conditions, the one most likely to cause diagnostic confusion either before, or even indeed at the time of operation. Symptoms typical of an intracranial tumor may be produced thereby."

Hence I feel that it it is not out of place to review the clinical, anatomic, physiologic, and pathologic knowledge available concerning the arachnoid, in the hope that it may stimulate interest among otolaryngologists having the opportunity to study such cases, which might lead to the eventual accumulation of sufficient observations, upon which some definite opinions regarding differential diagnosis might be founded.

A brief review of the anatomy of the arachnoid will help orient us in a discussion of this problem.

The brain and spinal cord are completely enclosed within three membranes. These are named from without inward; the dura mater, the arachnoid, and the pia mater. All three mem-

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branes develop through the rearrangement and condensation of the mesenchyme surrounding the brain and the spinal cord, and are therefore considered mesodermal in origin.

The arachnoid, or *serous membrane*, is the middle of the three meninges enclosing the central nervous system. It is a very delicate, nonvascular membrane loosely attached to the pia mater by numerous strands or trabeculae, and membranes which transform the subarachnoid space, situated between the pia mater and the dura mater and filled with cerebrospinal fluid, into a system of small and also larger communicating spaces. Between the trabeculae, more or less filling these spaces, is a spongy, delicate reticulum which is continuous with both the arachnoid and the pia mater. Thus, the arachnoid can hardly be said to have an inner surface. On the convex surface of the cerebrum the arachnoid is attached to the pia over the summits of the gyri by shorter strands; it does not penetrate into the sulci except at the sylvian and superior longitudinal fissures, but is stretched out and extends from one gyrus to another. In this manner large spaces arise over each sulcus. At the base of the brain at certain situations, the arachnoid is separated from the pia by wide intervals, which communicate freely with each other, and are named subarachnoid cisternae. In this region, the arachnoid is thicker and slightly opaque toward the central part; it covers the anterior lobes and extends across between the two temporal lobes so as to leave considerable intervals between it and the brain (anterior subarachnoid space).

It is in contact with the pons and under the surface of the cerebellum and the medulla oblongata (cisterna pontis). Another considerable interval is left between it and the brain, called the posterior subarachnoid space (cisterna magna). These two spaces communicate across the crura cerebelli. All cisternae communicate freely with each other.

The subarachnoid space completely surrounds the brain and is filled with cerebrospinal fluid, so that the brain may be said to lie on a water bed which serves to protect it from injurious contiguity with the bones.

Deaver has stated that the intimate connection between the arachnoid and pia makes the independent removal of the former very difficult. This is especially true over its convex surface where the two are closely adherent. However, according to certain investigators, the two membranes can easily be identified by inflating the subarachnoid space with a blowpipe.

The space over the hemispheres and temporal lobes is limited, but over the base is larger, forming the cisternae. By the intervention of the pons the cavity is subdivided into the anterior and posterior spaces. The posterior space communicates with the subarachnoid space of the spinal cord and the fourth ventricle, through the foramen of Magendie, and the paired foramina of Luschka which lie in the neighborhood of the vagus nerve.

The subarachnoid cisternae are six in number.

1. The cisterna cerebellomedullaris results from the arachnoid bridging over the interval between the medulla and the space between the cerebellar hemispheres. It is continuous with the subarachnoid cavity of the medulla spinalis at the level of the foramen magnum.

2. The cisterna pontis is a considerable space on the ventral aspect of the pons. It contains the basilar artery; it is continuous behind with the subarachnoid cavity of the spinal medulla, and with the cisterna cerebellomedularis; and in front of the pons with the cisterna interpeduncularis.

3. The cisterna interpeduncularis is a wide cavity where the arachnoid extends across between the two temporal lobes. It encloses the structures contained in the interpeduncular fossa and the arterial circle of Willis.

4. The cisterna chiasmatis is formed by the arachnoid extending over the optic chiasm to the upper surface of the corpus callosum. In this space the anterior cerebral arteries are seen.

5. The cisterna fossae cerebri lateralis is formed in front of each temporal lobe by the arachnoid bridging across the lateral fissure.

6. The cisterna venae magnae cerebri occupies the interval between the splenum of the corpus callosum and the superior surface of the cerebellum. It contains the great vein of Galen.

Projecting from the inner surface, especially along the dural sinuses, are seen numerous villus-like appendages, the arachnoid villi and Pacchionian granulations. These arachnoid villi or Pacchionian bodies are small, fleshy looking elevations, usually collected into clusters of variable size, which are present on the outer surface of the dura, in the vicinity of the superior saggital sinus, and a few are also found in other situations, for the most part along the other dural sinuses. Upon laying open the saggital sinus and the venous lacuna on either side of it, villi will be found protruding into its interior. They are not glandular in structure, but are enlarged normal villi of the arachnoid. They

are not seen in infancy, and very rarely before the third year. They usually are present after the seventh year; and from this time on they increase in size and number. In the adult, they are constant; as they grow they push the thinned dura before them and cause absorption of the bone from pressure and so produce the pits or depressions seen on the inner wall of the calvarium. It is through the arachnoid villi that the exchange of spinal fluid into the blood stream takes place. A small amount also passes into the larger veins directly at the point of their exit from the arachnoid.

The outer surface of the arachnoid is closely related to the dura mater and forms the inner limiting membrane of the subdural cavity. The outer surface is covered by a layer of mesothelium identical with the layer lining the inner surface of the dura and is continuous with it by way of the cells covering the nerves, and also of the blood vessels which pierce all three membranes.

The arachnoid derives its scanty blood supply from the cerebral vessels. These are very few and small. According to Bochdalek, the nerve supply comes from the motor root of the fifth, the seventh, and the eleventh cranial nerves.

Histologically, the arachnoid consists of bundles of white fibrous and elastic connective tissue intimately blended together. Each surface is covered by a layer of low cuboidal epithelium (mesothelium). The arachnoid is pierced by the cerebral and cerebellar vessels, and the cranial nerves. Around the vessels and nerves, this membrane projects for a short distance through the points of entrance and exit to the skull.

PHYSIOLOGY.

Little has been written concerning the physiology of the arachnoid other than that it serves as the outer membrane forming the closed subarachnoid space, which completely surrounds the brain and spinal cord, and in which is found the cerebrospinal fluid. The arachnoid also acts as a medium through which the spinal fluid is absorbed into the venous sinuses of the brain and the perivascular spaces of vessels passing through the subarachnoid space.

Weed proved that most of the fluid is absorbed into the venous sinuses and a very small amount passes into the perivascular spaces. He injected potassium ferrocyanide and iron ammonium citrate in a solution of normal physiologic sodium chloride, into the subarachnoid space of living animals at a

pressure of 150 millimeters of water. The nervous system and meninges were removed and fixed in acid solution which precipitated the salts as Prussian blue. Histologic examination proved the path taken by the injected material. If the animal were bled during the experiment, the dye could be seen passing through the arachnoid villi into the dural venous sinuses, and into the perivascular spaces. Weed further found that colloids were absorbed but slowly. The process of absorption is one of filtration. The pressure of the cerebrospinal fluid in the subarachnoid was 120 millimeters of water and exceeded the pressure in the venous sinuses by 5 to 50 millimeters of water.

The pressure of the spinal fluid depends upon a balance between its secretion and absorption. Anything that interferes with the function of the arachnoid villi will cause an accumulation of spinal fluid in the subarachnoid spaces. This is one of the causes for hydrocephalus.

PATHOLOGY.

Winkelman and Wilson, in a study on localized proliferations of the arachnoid, described the arachnoid meshes and stated that injection of foreign substances into the subarachnoid space caused changes in the arachnoid. They found that endothelial tumors may originate from these clusters and felt that trauma and infection might be contributing factors in their cause. They studied various age groups and came to the conclusion that there is a tendency for arachnoid proliferations to occur in persons past middle life.

Spurling has reported six cases of chronic cystic arachnoiditis. From his study, he felt that this is a disease entity which is characterized by localized, thickened, opaque arachnoid, bound to the pia mater by adhesions in the meshes of which there are accumulations of fluid. It may occur over the cerebrum, cerebellum, or spinal cord. The condition is often indistinguishable clinically from a tumor of the area involved. Spurling felt that the incidence of this disease must be much greater than one would imagine from reviewing the literature. He said that the etiologic background of the disease is not known, but suggested that local infections of low virulence or chronic irritation of the leptomeninges from absorption of a blood clot (one would infer that he meant trauma) are the most probable exciting causes of cystic arachnoiditis. He found that pertinent facts regarding the etiology, prognosis and treatment of this disease were scarce, and felt that this presented a problem of the utmost

importance which should engage the attention of both laboratory and clinical investigators.

Davis and Haven made a pathologic and histologic study of arachnoid tissue removed at operation in ten cases. Most of the patients were fairly young, and no formations typical of the cell clusters pictured by Cushing and Weed, and Winkelman and Wilson were noted. They classified the lesions into three main types: *1.* inflammatory, *2.* fibrotic, and *3.* hyperplastic. In one of their cases an arachnoid cyst was found overlying an acoustic neuroma on the right side. Similar cases have been reported by Cushing, who has said: "The frequency with which a dilated arachnoid cistern is found overlying an acoustic tumor is best explained by a circulatory obstruction. It explains the fluctuation of symptoms which these cases so often show early in the course of the disease and also for the fact that comparatively small tumors may at times produce marked general pressure disturbances, for as we shall see, the tumor actually lives within the lateral cistern, the growth together with the pocket of fluid may attain a considerable size. This is one reason why a circumscribed serous meningitis of this region may be difficult to distinguish from an actual acoustic tumor."

Cushing also has mentioned obstructive distention of the lateral cistern in connection with the matter of fluctuation of symptoms. The cistern of the lateral recess which sends its tubular prolongations around the Gasserian ganglion, and encompasses the seventh and eighth pairs of cranial nerves as well, is probably fed by the tuft of choroid plexus projecting from the foramina of Luschka. The plexus itself may be enormously displaced by the tumor.

Sachs has observed that in practically all posterior fossa lesions, there is a dilatation of the lateral and third ventricles. Such a dilatation must inevitably exert pressure on the pathways of the pons. He is absolutely convinced that many of the disturbances of the vestibular mechanism that the neurologists find are due to this associated internal hydrocephalus, and are, therefore, more the signs of general intracranial pressure than of any specific local pressure.

Barr and Rowan in a discussion of suppurative otitis and optic neuritis, in attempting to explain how comparatively mild attacks of serous meningitis may bring about vascular changes in the fundus of the eye, have stated that it is probable that localization has an important bearing on the causation of these changes.

In marked serous meningitis with very pronounced symptoms, the fluid is large in amount and under considerable pressure, and is widely distributed over the base of the brain. They felt that in the mild type, it was reasonable to suppose that the serous effusion is more localized, constituting abortive attacks cut short for some reason before becoming unduly spread. The effusion may take place in the arachnoid cisterns at the base of the brain, and one or the other of them may become a reservoir in which the effused fluid collects. They stated further, that there are at least two modifying influences at work, and the following statements are quoted from their report:

"*1.* There may in some individuals be conditions anatomical or constitutional specially favorable to the onset of optic neuritis, in a word idiosyncracy.

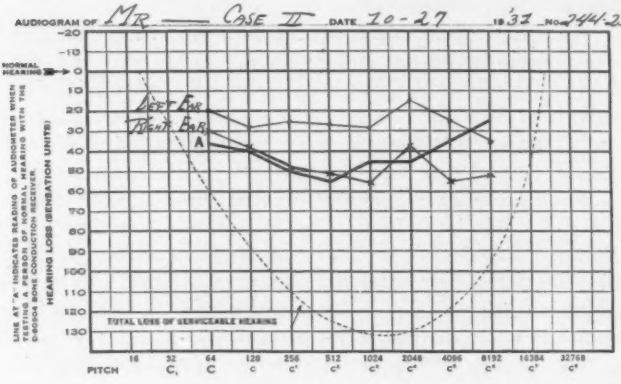
"*2.* The chemical character of the fluid exercising pressure is of importance. In serous meningitis the fluid, while no doubt sterile, insofar as pus forming organisms are concerned, is presumably not free from their toxic products. A very limited amount of pressure, therefore, may be quite sufficient in some individuals to excite changes in the optic nerves, when the evil effect of the pressure is enhanced by the chemical irritations of the toxins." This line of reasoning seems very practical to me, and on such a basis might be explained the part infection may play in the formation of cysts of the arachnoid. This is in keeping with Cushing's statement that often the chronic local arachnoiditis is the sequel of an otitis media which has left the ear so damaged as to impair auditory impulses and thus simulate the effects of an acoustic neuroma.

CLINICAL DATA.

Aside from the studies just mentioned, one may find many references and case reports of cysts of the arachnoid. Quain described such cysts in 1855. C. E. Ware, in 1858, described "Cysts from the Cavity of the Arachnoid." Wilks followed in 1865 with an article entitled, "Cysts in the Cavity of the Arachnoid." In 1903, Spiller, Musser and Martin in their work on "Cysts of the Spinal Cord," described cysts of the arachnoid in this region. The earlier articles have little reference to aural symptoms. In reviewing others, it is quite evident that the condition has been confused with that of subdural hematoma. In many published reports very meager records of the clinical and physical examination are included.

In two of Spurling's cases, the patients had vertigo, vomiting, diplopia, and nystagmus, but in reporting them no record of a functional ear examination was made in either case.

Horrax studied the records of 1264 cases tentatively diagnosed as brain tumor at the Peter Bent Brigham Hospital during a ten year period, and found that thirty-three of these proved to be arachnoid cysts. All showed generalized pressure symptoms with bilateral choked discs. The cerebellar symptoms were not pronounced in this series. There was usually nystagmus and sometimes involvement of the fifth, seventh or eighth cranial nerves. Reference was made to labyrinthine symptoms, but no attempt was made to analyze the onset or character of the symp-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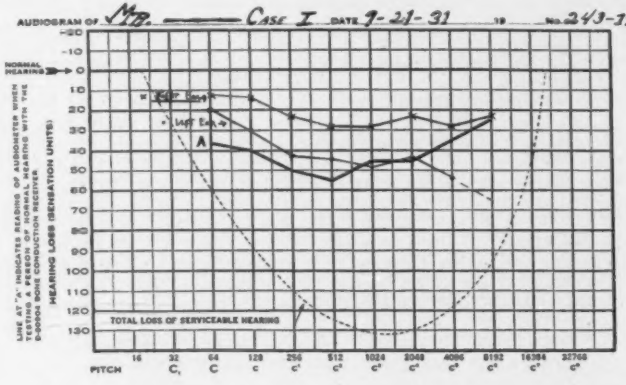
HEARING LOSS (SENSATION UNITS)
TOTAL LOSS OF SERVICEABLE HEARING
PITCH

toms in correlation with the functional or vestibular tests. The cases were classified as acute or subacute (nine cases), chronic (nineteen cases) and those with a history of otitis media (five cases). Of these thirty-three patients who were operated on, five died, and twenty-eight were cured or improved following operation.

We have found in the literature one case in which complete functional otologic examination was done, that of Monier-Vinard, Ramadier and Chausse. Their patient was a man, aged 40 years, who, six years before, without previous symptoms referable to his hearing, had been siezed suddenly with severe vomiting and vertigo, which had persisted. At that time he had had a definite sensation of objects passing to the right. Later he had noticed a decided decrease in hearing with tinnitus, particu-

larly on the left side. Attacks of vertigo recurred every fifteen days. In the intervals between attacks, the patient had experienced constant instability. He was given much medicine and had been operated upon for deviation of the septum. Over a period of six years, the vertigo gradually lessened, but the hearing in the left ear decreased and the tinnitus was violent.

The examination revealed nothing abnormal in the drums but there was bilateral deafness, which was worse in the left ear. The bone conduction was shortened. In Weber's test, the sound was localized to the right (good ear). There was elevation of the lower tones and reduction of the high tones. Romberg's sign was absent. The patient reeled to the left when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walking. Subsequent hearing tests showed improvement in the right ear, but there developed a feeling of pressure and heaviness in the left temporo-occipital region. There was no spontaneous nystagmus, and no past pointing. The caloric test showed absent responses from the left labyrinth, and a decrease in responses from the right vertical canal. Subsequent caloric tests showed a variation in the responses to stimulation of the right and left labyrinths. Eagleton's sign for hypertension was definitely present in this case. There was asymmetry of the left lower part of the face, hyperesthesia of the left side of the face, and anesthesia of the left conjunctiva, and later there was loss of the corneal reflex on the right. The visual fields were normal, there was slight bilateral papillary edema; the visual acuity was also low, but this was due to a refractive error.

A diagnosis of probable tumor of the left cerebellopontine angle was made. When the operation was performed, no tumor was found, but there was a cystic arachnoiditis in the region of the left cerebellopontine angle. The right side was explored with negative findings. A good result was obtained at operation. Total deafness continued on the left side, but there was a marked return of hearing in the right ear. The corneal reflexes became normal.

In correlating the findings, several facts were stressed by the authors as being of probable diagnostic importance in favor of arachnoid cyst over an acoustic tumor. These were the apparent onset of symptoms with marked Menier's symptom complex, to which loss of hearing was secondary, which is of rare occurrence; and the absence of spontaneous nystagmus.

They concluded that "pseudo tumors, such as arachnoid cysts of the cerebellopontine angle, manifest themselves as do acoustic tumors with symptoms referable to the eighth pair of cranial nerves. Most patients having symptoms of acoustic tumors are referred to the otologist first, and he, more than anyone else, has the opportunity of studying these symptoms from their start. However, all too frequently, he does not avail himself of this opportunity for study, and fails to make a complete functional examination of the ear."

Dennis, in abstracting this article expressed regret that the technique of Jones and Fisher had not been used.

Following are the records of the two patients who were studied at the Cleveland Clinic:

The first patient, a man aged 56, had been treated for various diseases and finally was referred by his physician for an investigation of the prostate. He was seen on September 21, 1931. However, his chief complaint was vertigo. There was no history of injury. He had had typhoid fever thirty-three years previously; aside from this there had been nothing of significance in the past history. The patient had been in good health until two and one-half years prior to his admission. At that time, he had begun to have periodic attacks of vertigo, accompanied by a sensation of heaviness and numbness in the left occiptal region, together with faintness, nausea and projectile vomiting. When he had an attack he would stagger like a drunken man;

between attacks he had a normal gait. There had been a gradual loss of hearing in the left ear, over a period of five years. When he was examined, he complained of almost constant tinnitus in the left ear. He had noticed, too, that the tinnitus increased just preceding the attacks of vertigo. At first these occurred about every two months, but during the six months just before admission, their frequency had increased slowly until he had had seizures every two or three days. In the week just previously, he had had as many as eight to ten attacks in one day. A year before, in one of these he had lost consciousness and had fallen, and two days previous to admission, he had again become unconscious and had fallen to the floor, striking his right shoulder and his left eye. His wife said that during this attack, his eyes stared, and had a glassy look, but he had regained consciousness almost immediately. There was no disturbance of vision, although objects seemed to pass in front of him. During the two years of his illness, he had lost 14 pounds in weight. Various diagnoses, including cholecystitis, anemia, cerebral arteriosclerosis and epilepsy had been attached to his malady elsewhere.

Examination revealed that his general physical condition was good. The systolic blood pressure was 130 and the diastolic pressure was 74. Pulse rates ranged from 55 to 65. There was bilateral absence of corneal reflexes. The Romberg sign was present to a slight degree. There was impaired sensation in the second and third divisions of the fifth nerve on the left side. Sensation was diminished on the left side of the pharynx. The function of the fifth, eighth and ninth nerves on the left side was impaired, but there was no evidence of involvement of the seventh nerve on this side. There was jerky nystagmus on looking to the right and to the left, which at times was almost vertical. There was no past pointing. Both ear drums were bright, Hearing was slightly impaired in the right ear, showing a drop beginning with C_1 128 d.v. In the left ear, C, C_1 and C^2 were heard short, and C^3 and C^4 were much decreased. Weber's test showed that the sound was not localized. Bone conduction was prolonged over the left mastoid (the diseased side) and was normal over the right. Rinne's test was positive on the right and negative on the left. The caloric test, with a continuous flow of water at 68° called forth no responses from either the right or the left vertical canals after five minutes. There were normal responses from both horizontal canals.

The examination of the eyes showed that the media were clear, and the discs were of good color. There were vascular changes in the choroid on both sides, with a slight choroiditis. There was no refractive error, which might have accounted for the vertigo. Roentgenograms of the petrous portion of the temporal bone showed nothing abnormal. All serologic tests gave negative results. The spinal fluid pressure was 110 millimeters of water.

A diagnosis of acoustic tumor on the left side was made, and operation was advised and performed by Dr. James Gardner of the department of neurosurgery. The operation was done on September 28, 1931; the bone over the left cerebellar hemisphere was removed and the dura was opened widely. The pressure was not increased, although there seemed to be an abundance of cerebrospinal fluid, and the arachnoid in the region of the cisterna magna appeared to be somewhat thickened. The left cerebellar hemisphere was elevated, and an arachnoid cyst in the region of the left cerebellopontine angle was ruptured. A quantity of clear, colorless, cerebrospinal fluid escaped. The seventh and eighth nerves were readily exposed as they passed into the internal acoustic meatus. There were several filmy arachnoid adhesions about the nerve, but there was no evidence of a solid tumor. Since the function of the eighth nerve was largely destroyed, it was thought best to sever it in order to insure relief from the tinnitus, vertigo and nausea. The seventh nerve was identified by stimulation with a faradic current after which the eighth nerve was sectioned.

An examination about two weeks after operation (Oct. 12, 1931) showed that the vertigo, tinnitus, and nausea had entirely disappeared. The ear drums appeared normal, but there was complete deafness on the left side. No bone conduction could be demonstrated, and there was a complete paralysis of the left seventh nerve. The patient was examined again on November 10, about six weeks after operation. At that time rapid horizontal nystagmus on looking to the right was noted, and there was slow horizontal nystagmus on looking to the left. Sensation had returned to the right cornea, and was considerably improved in the left cornea. Paralysis of the left seventh nerve remained. The patient's general condition was excellent.

An interesting fact in connection with this case is that the patient had been in the hospital under treatment for cholecystitis, when these attacks first began, and following the neurologic

operation, he had had marked relief from the gastro-intestinal symptoms.

The second patient, a man aged 48, had been well until about five years before he came to the Cleveland Clinic in October, 1931. While working in a stooping position, he had suddenly became very dizzy; the vertigo was followed immediately by vomiting for several hours. The following day he felt well except for a ringing in his right ear, which had continued ever since. He had had a second attack of vertigo and vomiting five weeks later, and during the next two years he had had about twelve or fourteen such seizures, each lasting about twenty-four hours. Since then, they had appeared more frequently and were of longer duration. About six months before he visited the Clinic, a spinal puncture had completely relieved the vertigo, projectile vomiting and tinnitus. He had been entirely free from symptoms for about five months, at the end of which time they reappeared in a still more violent form. A second spinal puncture gave no relief from the symptoms which had persisted during the five weeks before he presented himself.

Vertigo was not constant, but the patient was afraid to walk on the street alone. On several occasions he had lost consciousness for a minute or so. He complained of some headache which was always frontal, but he had no numbness, paralysis, or weakness. There had been no change in speech and no diplopia.

The general physical examination revealed nothing of particular significance. His blood pressure was 130 systolic, 85 diastolic, his pulse rate was 96 and his temperature was normal. There was a slight inequality of the pupils, and corneal anesthesia was present on both sides. Examinations of the fundus and visual fields disclosed no abnormality. There was no spontaneous nystagmus. The ear examination revealed marked impairment of hearing in the right ear and marked decrease in caloric reactions (water 68°) from both the vertical and horizontal canals. Examination of the left vestibular labyrinth showed nothing abnormal. Bone conduction was present over both mastoids. The caloric test produced vertigo and nausea.

Roentgenograms of the skull gave negative findings. The spinal fluid pressure was normal, and the response to unilateral jugular compression was equal on the two sides. The blood counts were within normal range and all serologic tests produced negative results.

It was felt that the patient's symptoms were due rather to an irritative lesion of the right eighth nerve than to a tumor. The absence of spontaneous nystagmus and of increased intracranial pressure, and the presence of normal though decreased responses from the left labyrinth seemed to indicate that the lesion was not an intracranial tumor. Dr. Gardner felt that section of the eighth nerve should be done. The patient's symptoms were so severe that surgical intervention was necessary.

The operation was performed October 30, 1931. The bone was removed over the right cerebellar hemisphere. The dura was opened widely, and the right cerebellar hemisphere was elevated by a lighted retractor. Immediately a large quantity of clear cerebrospinal fluid escaped. The seventh and eighth nerves were exposed as they made their exit from the internal auditory meatus, about which there were some rather dense arachnoid adhesions. There was some difficulty in distinguishing between the seventh and the eighth nerves, but after stimulation with an electrode, the eighth nerve was sectioned and the wound was closed. It was apparent after the operation that the nerve had not been completely sectioned, and hence a second operation was performed five days later, at which time all the fibers entering the internal acoustic meatus were severed.

An examination on November 11, 1931, showed that in the right ear there was no labyrinthine response, and the patient was completely deaf on this side. Neither were there any reactions to the caloric test. In the left ear the hearing was quite good, and the reactions of the labyrinth were entirely normal in both the horizontal and vertical canals. The tinnitus had disappeared and the patient had experienced no sensation of vertigo since the operation. There was complete facial paralysis, but no disturbance of taste, and he had a good appetite.

COMMENT.

These two case reports have been offered in order to present a problem. In each case there was some irregularity in the symptoms which might have suggested a lesion other than tumor of the cerebellopontine angle.

The same criticism applies to me that I have applied to others earlier in this paper: I am unable to present complete case histories and proper otologic examinations on the material at hand. This is due to a lack of appreciation of the value of complete functional ear examination if the diagnosis seems certain enough to warrant an exploration.

One patient proven at operation to have an arachnoiditis was not questioned as to ear symptoms, and an ear examination was not asked for; this was a boy, aged 20, who fell, striking his occiput. He became unconscious for about one minute; he had a headache for a few hours and was then completely free from symptoms. Later, one morning on arising he suddenly vomited; afterwards he had frequent headaches and vomiting spells, with intervals of complete freedom from symptoms. He had early edema of the optic discs, which was more marked on the left. Spinal fluid pressure was increased; fluid was xanthochromic and his condition was diagnosed as probably due to a subdural hematoma. Following operation he died and no autopsy was obtained. I mention this case to emphasize that these patients have periods of improvement. This appears to be one rather constant characteristic applicable to all of the cases investigated.

In the first case reported here, it is interesting that there was some hearing in the left ear with prolonged bone conduction on that side, with no response from either vertical canal, with normal responses from both horizontal canals and with no eye changes. If I were to encounter again a patient with such bizarre symptoms I would be suspicious of disease of the arachnoid.

In the second case, there had been sudden onset of symptoms with complete remission; also spinal puncture completely relieved the symptoms once; eye grounds and visual fields were normal; there was no spontaneous nystagmus; some responses remained to caloric stimulation on the right side with normal responses on the left. This ruled out acoustic neuroma and while it seemed at the time that degeneration of the right eighth nerve might account for the symptoms, yet the history of the onset of symptoms while stooping, the severe vertigo followed later by tinnitus, and the fact that two years after the onset of symptoms a spinal puncture gave entire relief from all symptoms for five months might have rather definitely ruled out such a diagnosis and might have aroused suspicion of the presence of an arachnoid cyst.

From the present meager data, I believe that it is impossible to form any conclusions, but it might be that further study would elicit information which might make possible a differential diagnosis in these cases. The subject has been given practically no consideration by otologists, and it would seem that there has been a decided neglect on the part of neurologists

and neurologic surgeons to have complete functional ear examinations made before operation.

A very complete history, making a point of ascertaining the sequence of symptoms, together with a complete vestibular and cochlear examination might do much to make possible a better diagnosis. There may be a variance in the age groups of patients with acoustic tumor and those with arachnoid cysts. Duration of symptoms may also be important.

Fisher has set forth very definitely the cochlear-vestibular findings of tumors of the cerebellopontine angle. Eagleton has stated that the vestibular manifestations of intracranial pressure, especially of the posterior fossa, are definite and of general diagnostic value. And to quote Cushing again: "It is true that arachnoid cysts may produce symptoms which simulate angle tumors, but though tinnitus and vertigo and a Menier's syndrome may occur, complete deafness and such pronounced pressure symptoms are hardly to be expected."

Following Henschen's views that acoustic tumors arise more often from the vestibular nerve, and that a complete vestibular paralysis is more frequent than a complete cochlear paralysis. it may be possible on the irregularity of the symptoms alone to throw the weight of evidence in favor of arachnoid cyst over acoustic tumor.

SUMMARY.

1. The question is raised as to whether or not the acquisition of further data might enable otologists to distinguish between acoustic tumors and cysts of the arachnoid, and a plea is made for increased interest in the problem involved.

2. The anatomy and physiology of the arachnoid are briefly reviewed.

3. Various statements are quoted from the literature concerning the pathology of cystic arachnoiditis.

4. The older clinical reports are mentioned briefly, and one case from the literature of arachnoid cyst in which functional ear examinations were made before operation, is reviewed somewhat in detail.

5. Two cases of arachnoid cyst seen at the Cleveland Clinic are reported.

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THE NEW YORK ACADEMY OF MEDICINE.

SECTION OF OTOLARYNGOLOGY.

Meeting of Dec. 21, 1932.

Diathermy: Results; Good, Bad or Indifferent, in Nose, Throat and Ear Conditions. Dr. L. M. Hurd.

(To be published in a subsequent issue of THE LARYNGOSCOPE.*)*

Case of Acute Tonsillitis and Cervical Adenitis Treated with Diathermy. Dr. L. M. Hurd.

H. P., white, male, age 40 years. Was admitted to the hospital on Oct. 17, 1932, with history of having had three electrocoagulation treatments of tonsils at weekly intervals. Last treatment was one week before admission.

C. C.: Sore throat and enlarged and tender cervical glands. Right, three plus. Left, two plus. Three days duration.

P. H.: No previous illnesses. No previous operations.

F. H.: Negative.

Ears, eyes and nose, negative. Pharynx: Both tonsils inflamed, and covered with sloughing mass, redness extending to pillars. The soft palate and uvula was edematous. Neck: Anterior cervical glands on both sides enlarged and tender. Larger on right. Chest, negative. Heart, negative. Abdomen, etc., negative.

Provisional Diagnosis: Acute tonsillitis. Acute cervical adenitis.

The temperature on admission was 99°. The following day the temperature rose to 102° and 103°. The throat reaction and swelling of neck with resulting dysphagia increased. On the third day the swelling on the right side of neck was incised. No free pus was obtained. Drain was inserted, and hot wet dressings were instituted. Following this the patient had chill and temperature rose to 106°. White count, 23,600; polys., 82 per cent; blood culture, negative.

The temperature remained high for the succeeding days, ranging from 102° to 105°. There was moderate amount of drainage from the wound. Swelling extended from right side of face to clavicle below and protruding to midline. Patient was extremely ill. Blood culture on Nov. 11, 1932, was negative. R. B. C., 3,500,000; W. B. C., 26,800; polys., 78; lymphs., 22. Culture from wound was staphylococcus aureus.

Diagnosis: Deep cellulitis of right side of neck. Mercurochrome injected in external wound came through tonsillar area to pharynx.

On Nov. 11, 1932, multiple incisions were made into swelling. One long incision along anterior belly of sternomastoid muscle and smaller incisions anteriorly, and in posterior triangle. Drains were inserted, and hot wet dressings continued. A blood transfusion was given at this time. Patient continued very ill. Considerable tissue sloughed out of area involved, along with profuse discharge of pus.

On Nov. 15, 1932, patient developed erysipelas about wound, which spread over face and scalp, lasting about one week. He was given daily injections of erysipelas streptococcus antitoxin for first three days of this complication.

Following this, the patient developed a series of furuncles and boils which lasted until present date.

Patient was discharged Dec. 8, 1932. Temperature had been normal for past two weeks. Cellulitis of neck about well. Throat reaction had entirely subsided. The tonsils and pillars are a mass of scar tissue. The major portion of both tonsils still remain and are embedded in this mass.

DISCUSSION.

DR. DAVID H. JONES: Our principal aim should be to develop the best possible technique in our work, and to use it properly, freely admitting our mistakes or wrong methods, and attempting to correct them.

One hears about removing tonsils by electricity through the radio, newspapers, magazines, and have just learned that the Life Extension Institute is

advocating it to people who come to them for examination. This propaganda has become so extensive, the laity being told that after a few treatments they will expectorate their tonsils in five days, and it was your Chairman's purpose to attempt to clear up this situation, evaluating the advantages and disadvantages of electrocoagulation.

During the past three and one-half years at Manhattan Eye, Ear and Throat Hospital there have been 39,289 patients operated upon for the removal of adenoids and tonsils, and we have endeavored to perfect our technique eliminating hemorrhages, pieces left, pillars torn, and all other complications as far as possible. In order to evaluate the method of electrocoagulation of tonsils, two men (Dr. Jasper and Dr. Hubert) were selected to treat suitable patients during the past one and one-half years. Three different machines were used.

All adherents of this method claim its usefulness in certain selected cases: Hemophiliac—how many have each one of us seen? One in 39,289 cases. Heart—past six months 7,982 patients operated upon—92 cardiac cases. Aged 45 and over—past six months 80 patients operated upon, seven cardiac, 66 local, 14 general.

Postoperative remnants of tissue. Diseased tonsils in tuberculosis, which will be spoken of later.

Dr. J. L. Myers, A. M. A., 1932, submitted a questionnaire to 44 men, using different methods of electrosurgical technique. Thirty-one answers were received, which he has divided into four groups.

First group: Those using electrotherapy for over 20 years, whose answers stated that they had developed a technique which was safe and sure.

Second group: Formerly used accepted surgical tonsillectomy, now claims to use electrosurgical technique. One answer: safety of patient, better results, no worry to doctor about patient's condition.

Third group: Otolaryngologists who have heard reports regarding electrocoagulation have taken it up but owing to its time consuming treatment are using it only in selected cases.

Fourth group: Comprises men from all schools of therapy who are unable to perform a surgical tonsillectomy, and after a three-day course have purchased a high frequency machine, and are prepared to operate.

In answer to the question: What complications have you had? Seven reported none; one, practically none; one, none in ten years; one, none in 700 cases, and a few reported slight secondary hemorrhages.

Other Complications: Infection of stump; pharyngeal abscess (2): tonsillitis during period of operation (2): destruction of pillars (1): piece of tonsil in upper pole covered by mucous membrane (2): edema of uvula and pillar (3): peritonsillar abscess (4): cellulitis (3): edema of larynx (1): postoperative hemorrhage (5): severe hemorrhage (5).

One writer, in the first paragraph of an article published in the October, 1932, issue of the Archives of Physical Therapy, X-ray and Radium, states that six years ago he was almost alone in presenting the simplicity and safety of electrocoagulation of tonsils, but he closes his paper with this sentence: "I can authoritatively state that it requires more skill, deftness and experience to remove tonsils by diathermy than by the old surgical procedure." He also states that electrocoagulation of tonsils will eventually be the routine operation. He operates on children, using gas-oxygen anesthesia, and as each tonsil receives six treatments, it means twelve anesthesias. It might be interesting to hear what this same writer says regarding hemorrhages. "Some final conclusions. Do we ever get any hemorrhages or severe bleeding? Out of some 7,000 treatments a year, I may have six or eight patients who have bleeding. This, I believe (but do not know it to be a fact), is due to two things, either under-coagulation or a premature detachment of some of the superficial pus. When this arises, if the bleeding is slight, we remove any clot that may be in the fauces, and make an application of 20 per cent solution of nitrate of silver. If the patient should have a slow coagulation time, or be a known bleeder, we may give an injection of 10 or 20 cc. of coagulin ciba, and repeat ad libitum, and then coagulate the bleeding point with our needle, which in fact is all that I usually do. In more than 40,000 treatments I have found that this bleeding is simply capillary oozing, and in all cases is very easily controlled. I have never encountered a "spurter" nor have I ever had to make a night call on account

of bleeding. If, and when this does happen, I simply instruct the patient to apply some ice to the throat, and in the morning come to the office."

If the above technique as outlined is followed, you must get nothing but a satisfactory result.

Another writer states that: "The end-results are not as clean as a well performed surgical tonsillectomy, as there is usually some thickening in the anterior and posterior pillars, and a small buried tonsil is a man's job. It is also possible to have secondary hemorrhage, discomfort and infection just as is found with any other method." He also states that, "partial removal of the tonsil eliminates the focus of infection, and will preserve the contour: this is called diathermocryptectomy."

Another writer claims that considerable misunderstanding has occurred regarding the number of patients who fail to complete the course of treatments because the dread of progressive treatments is a greater strain on the nervous patient than the single nervous shock of surgical removal; these patients being seen later with a recurrence of their old complaints, tonsillitis, peritonsillar abscess and infection. Judging from this writer's article, he has no hemorrhages, patient able to eat immediately after operation, no untoward reactions or complications.

(Still quoting) "The faucial fossa are clean, the shiny aponeurosis of the constrictor muscle may be seen through the translucent capsule if that anomalous structure be present. A picture which without doubt, in the completed case approaches most closely a perfect tonsillectomy." And still in his discussion in September, 1932, he states that he would much rather do the orthodox tonsillectomy.

Another reason for this method is that it is bloodless, but as so many secondary hemorrhages have occurred this feature is not now stressed, and twenty treatments are now being given instead of four, according to an editorial in the June, 1931, issue of the Archives of Physical Therapy, X-ray and Radium.

In the October, 1932, issue of the Surgical Clinics of North America, an article from the clinic of Dr. Geo. Shambaugh at Rush Medical College, by Dr. W. J. Yonker and Dr. C. L. Dougherty states their conclusions are that for tonsils and tonsil stumps this method was too costly in loss of time and discomfort to the patient, and it is not free from secondary hemorrhage, and when it occurs, the tonsils being so friable, the control of hemorrhage is very difficult. Their end-results have not accomplished complete removal of tonsils nor have they seen a patient treated elsewhere where the tonsil fossae were free from tonsil tissue, nor do they believe that partial removal will answer.

The following is the abstract of a letter received which reports an emergency tonsillectomy: "A man, age 33 years, had electrocoagulation treatment on his right tonsil on Dec. 27, 1931. On Jan. 2, 1932, began to bleed from his right tonsil. He went to hospital and attempts were made to stop bleeding, but were unsuccessful. I was called in about 1 a. m., and after working 15-20 minutes it became apparent that ordinary measures could not be used. Hence patient was anesthetized and tonsil was removed. While I was at it I also removed the left one. There was no further bleeding."

Dr. R. G. Brown and Dr. J. V. Duhig, Medical Journal, Australia, July 2, 1932, state, "that diathermy treatment does cause pain, and examination of remnants of tonsil tissue revealed abscesses and infection showing that remaining tonsillar portions are not sterile. Marked clinical improvement followed surgical removal of tonsil tissue left after the coagulation treatment."

After reading articles by many writers and hearing the super-enthusiastic statements by discussers at meetings, is it any wonder that the high pressure salesmen (about whom so much has been written) and manufacturers of machines are spreading a wave of propaganda throughout the country, using the glowing contributions of these writers, as pamphlets which are sent to us (for instance, a pamphlet, "The last word in tonsillectomy," including diathermy or electrocoagulation) and during this period of depression many machines are sold to Dr. Myers' fourth group?

(To be continued.)